Ground Cloud Dispersion Measurements During The Titan IV Mission #B33 (15 October 1997) at Cape Canaveral Air Station

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13. ABSTRACT (*Maximum 200 words*)

This report presents plume imagery documenting the development and dispersion of the Titan IV #B33 launch ground cloud at Cape Canaveral Air Station on 15 October 1997 at 0443 EDT. Also presented are pertinent meteorological data taken from towers, Doppler radars, and rawinsonde balloons.

IR cameras were used at four locations around the launch site to track the trajectory and time evolution of the exhaust ground cloud for 1.5–2.5 min following launch. Meteorological data were collected to improve understanding of cloud dispersion and to use as input during model simulations and evaluations. Rawinsonde balloon data, 915 MHz Doppler radar data, and meteorological tower data were collected and archived. These data and similar data from other launches will be used to determine the accuracy of atmospheric dispersion models such as the Rocket Exhaust Effluent Diffusion Model (REEDM) in predicting toxic hazard corridors (THCs) at the USAF Eastern and Western Ranges.

Reduction of available imagery data yielded limited information on cloud rise and dispersion. The imagery showed that the bottom edge of the launch cloud rose above the altitude of the bottom of the atmospheric clouds (514 m AGL) within 2.3 min after launch. REEDM 7.08 predicted that the bottom edge of the launch cloud would stabilize at 480 m AGL. The bottom of the actual launch cloud therefore rose at least 7% higher than predicted by REEDM 7.08. Analysis of the imagery also showed that the rising cloud had an air entrainment coefficient (ratio of increase in diameter to increase in altitude) of 0.39. This is significantly smaller than the default air entrainment coefficient of 0.64 that is used in REEDM 7.08.

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Preface

The Air Force Space and Missile Systems Center's Launch Programs Office (SMC/CL) is sponsoring the Atmospheric Dispersion Model Validation Program (MVP). This program is collecting launch cloud dispersion data that will be used to determine the accuracy of atmospheric dispersion models, such as REEDM, in predicting toxic hazard corridors at the launch ranges. This report presents launch cloud dispersion and meteorological measurements performed during the #B33 Titan IV launch at Cape Canaveral Air Station on 15 October 1997.

An MVP Integrated Product Team (IPT) led by Lt. Bill Kempf (SMC/CLNER) is directing the MVP effort. Dr. Bart Lundblad of The Aerospace Corporation's Environmental Systems Directorate (ESD) is the MVP technical manager. This report was prepared by Mr. Norm Keegan (ESD) and Dr. Lundblad from materials contributed by personnel participating in the #B33 launch cloud dispersion measurements.

Infrared imagery measurements were made of the launch cloud by Ms. Karen Foster, Mr. Gary Harper, Mr. Brian Kasper, Dr. Don Stone, and Mr. Jess Valero of The Aerospace Corporation's Environmental Monitoring and Technology Department (EMTD). They were assisted by Mr. John Ligda and Mr. Richard Reyes of Aerospace's Eastern Range Directorate and Dr. Bart Lundblad. Mr. Doug Schulthess of Aerospace's Eastern Range Directorate coordinated camera site selection and logistical support. Ms. Foster and Dr. Stone digitized the imagery data for analysis by Dr. Abernathy. The description of the cloud imagery results was prepared by Dr. Abernathy.

The meteorological data displayed in this report were provided by Mr. Randy Evans of the NASA Applied Meteorology Unit and by Mr. Doug Schulthess. The REEDM launch cloud dispersion prediction was calculated by Dr. Robert Abernathy.

The #B33 mission was the eleventh Titan IV launch for which usable launch cloud dispersion data was collected by MVP. The previous missions were #K7, #K23, #K19, #K21, #K15, #K16, #K22, #K2, #K13, and B-24.

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Executive Summary

This report presents plume imagery documenting the development and dispersion of the Titan IV #B33 launch ground cloud at Cape Canaveral Air Station (CCAS). The launch occurred on 15 October 1997 at 0443 EDT. The report also presents pertinent meteorological data taken from towers, Doppler radars, and rawinsonde balloons.

The imaging team used infrared cameras at four locations around the launch site (LC-40) to track the trajectory and time evolution of the vehicle's exhaust ground cloud for 1.5–2.5 min following launch. Subsequent imagery of the cloud was obscured by atmospheric clouds. Meteorological data were collected to improve understanding of cloud dispersion and to use as input during model simulations and evaluations. Rawinsonde balloon data from shortly before launch, 915 MHz Doppler radar data from shortly before and after launch, and meteorological tower data from shortly before and after launch were collected and archived. These data and similar data on other Titan IV launches (past and future) will be used to determine the accuracy of atmospheric dispersion models such as the Rocket Exhaust Effluent Diffusion Model (REEDM) in predicting toxic hazard corridors (THCs) at the USAF Eastern and Western Ranges. These THCs assess the risk of exposing the public to HCl exhaust from solid rocket motors or hypergolic propellant vapors accidentally released during launch operations.

Reduction of available imagery data (from the first 1.5–2.5 min following launch) yielded limited information on cloud rise and dispersion. The imagery showed that the bottom edge of the launch cloud rose above the altitude of the bottom of the atmospheric clouds (514 m AGL) within 2.3 min after launch. REEDM 7.08 predicted that the bottom edge of the launch cloud would stabilize at 480 m AGL. The bottom of the actual launch cloud therefore rose at least 7% higher than predicted by REEDM 7.08. Analysis of the imagery also showed that the rising cloud had an air entrainment coefficient (ratio of increase in diameter to increase in altitude) of 0.39. This is significantly smaller than the default air entrainment coefficient of 0.64 that is used in REEDM 7.08.

1. Introduction

Launch vehicles that employ solid propellant rocket motors release exhaust ground clouds containing large quantities of hydrogen chloride (HCl) into the launch areas at Cape Canaveral Air Station (CCAS) and Vandenberg Air Force Base (VAFB). Large quantities of hazardous liquid fuels and oxidizers could also be released as a result of propellant transfer accidents or launch vehicle failures. The Air Force uses atmospheric dispersion models to predict the downwind diffusion and concentration of toxic launch clouds. Collection of launch cloud data is required to test and validate the performance of these dispersion models.

The Air Force range safety organizations at Patrick Air Force Base (45 SW/SE) and VAFB (30 SW/SE) are responsible for assuring that launches occur only when meteorological conditions will not expose nearby public areas to hazardous levels of launch exhausts and propellant vapors. Predictions of toxic hazard corridors that extend into public areas can lead to costly launch delays. The use of non-validated models requires the use of conservative launch criteria. The development and validation of more accurate atmospheric dispersion models is expected to increase launch opportunities and significantly reduce launch costs. The Space and Missile Systems Center's Launch Programs Office (SMC/CL) established the Atmospheric Dispersion Model Validation Program (MVP) to collect launch cloud data and to use the data to test and validate current and future atmospheric dispersion models at the ranges.

The MVP effort involves the collection of data during Titan IV launches at CCAS and VAFB to characterize HCl launch cloud rise, growth, and stabilization, as well as launch cloud transport and diffusion. These data, along with data collected during tracer gas releases, will be used to determine the capability of the Rocket Exhaust Effluent Diffusion Model (REEDM) for predicting toxic hazard corridors at the ranges. REEDM is used at CCAS and VAFB to predict the locations of toxic hazard corridors in support of launch operations. It is applied to large heated sources of toxic air emissions such as nominal launches, catastrophic failure fireballs, and inadvertent ignitions of solid rocket motors. It uses launch vehicle and meteorological data to generate ground-level concentration isopleths of HCl, hydrazine fuels, nitrogen dioxide, and other toxic launch emissions. Launch holds may occur when REEDM toxic concentration predictions exceed adopted exposure standards. REEDM is a unique and complex model based on relatively simple modeling physics. It has a long development history with the Air Force and NASA, but has never been fully validated. Validation of REEDM has been identified as a range safety priority.

The MVP has been organized and is being directed by the MVP Integrated Product Team (IPT). SMC/CL is serving as the IPT leader, while The Aerospace Corporation's Environmental Systems Directorate serves as the IPT technical manager. The IPT consists of personnel with expertise in atmospheric dispersion modeling, meteorology, and atmospheric dispersion field studies. MVP participants include personnel from SMC, 30 SW, 45 SW, Armstrong Laboratory, The Aerospace Corporation, NASA, NOAA, and contractors. Key functions include program planning, field data collection, data review and compilation, range coordination, and model validation.

This report presents the results of measurements performed at CCAS during the Titan IVB-33 launch on 15 October 1997 at 0443 EDT. This was the second Titan IV launch to use the new and larger Solid Rocket Motor Upgrade (SRMU) booster. Infrared measurements were made on the ground cloud from four locations near the launch site (LC-40) to monitor cloud growth, stabilization, and trajectory. The imagery results are presented in Section 2 and REEDM predictions of ground cloud stabilization heights and surface concentrations are presented in Appendix A. Measurements of meteorological data are tabulated in Appendix B.

Atmospheric clouds prevented the complete observation of cloud stabilization. Imagery analysis yielded the cloud's rise rate, expansion rate, speed, and bearing during the first 1.5 to 2.5 min after launch. The top of the cloud rose into an atmospheric cloud cover after 1.5 min. The bottom of the cloud was tracked until 2.5 min after launch. Analysis of the limited cloud imagery showed that the bottom edge of the cloud rose to an altitude exceeding 514 m AGL (point at which it was obscured by atmospheric clouds) while REEDM 7.08 predicted that the bottom edge of the cloud would stabilize at 480 m AGL. The imagery results presented in this, as well as other MVP reports, will allow the accuracy of REEDM and other launch range atmospheric dispersion models to be determined over the range of possible meteorological conditions.

2. Imagery of the Titan IV #B33 Ground Cloud

[The material in this section was contributed by R. N. Abernathy and K. L. Foster of the Environmental Monitoring and Technology Department of The Aerospace Corporation's Space and Environment Technology Center.]

2.1   Background

On 15 October 1997, the Titan IV #B33 mission was successfully launched from Space Launch Complex 40 (SLC-40) at Cape Canaveral Air Station (CCAS) at 04:43 EDT (08:43 GMT). This section describes the quantitative exhaust cloud imagery data collected by each of three imagery sites during the 2.5 min immediately following the launch from SLC-40. This chapter also describes the data acquisition hardware and analysis software. The two-dimensional cloud images obtained by the various imagery sites were combined to produce stereoscopic 3-D information. This analysis yielded the cloud's rise rate, expansion rate, speed, and bearing during the first 1.5 to 2.5 min after launch. The top of the cloud rose into a low-lying cloud cover after 1.5 min. However, the bottom of the cloud was tracked until 2.5 min after launch.

The quantitative imagery-derived ground cloud data are reported here in several graphical formats to facilitate comparison with REEDM predictions (Appendix A) and rawinsonde sounding data (Appendix B). For clarity, this section includes some data from the appendices. It is apparent from review of this section, that these data are useful for validating current and future dispersion models.

The purpose of this report was to document the quality and quantity of the #B33 exhaust cloud imagery data available for validating dispersion models. To facilitate the comparison of these data to individual dispersion model runs, the imagery-derived #B33 exhaust cloud imagery data are available as comma-separated-variable files providing time and position for various ground cloud features. When collected, the raw visible imagery data are archived on VCR tapes. The raw infrared imagery is archived on DAT. The selected infrared images analyzed for this report are also archived on magneto-optical disks as digital image files.

2.2   Introduction

This section summarizes the results of quantitative infrared (IR) imagery of the exhaust cloud from the Titan IV #B33 launch from SLC-40 at CCAS on 15 October 1997 at 04:43 EDT (08:43 GMT). Personnel from The Aerospace Corporation's Environmental Monitoring and Technology Department (EMTD) supported this launch with the deployment of four complete platforms of the Titan IV dedicated Visible and IR Imaging System (VIRIS). For the #B33 early morning launch, the IR imagery permitted the post-launch quantitative analysis of the ground cloud's movement and growth as a function of time.

The imagery sites chosen for the #B33 launch were

- on the railroad tracks across from <u>UCS-4</u> (north-northwest of SLC-40),

- at the third bollard along the northeast edge of the pond at <u>Press Site</u> (northwest of SLC-40),

- at <u>UCS-2</u> (southwest of SLC-40), and

- on top of <u>Tower</u> 60691 along Hangar Road near Skid Strip (south-southwest of SLC-40).

UCS stands for Universal Camera Site. Each site recorded only IR imagery of the exhaust cloud since it was too dark for visible imagery. Technical difficulties prevented the quantitative analysis of the UCS-2 imagery. Low-lying atmospheric clouds prevented imagery of the rise of the top of the cloud to its stabilization height. Therefore, the top and middle of the cloud were only tracked until 1.5 min after launch. The bottom was tracked for 2.50 min.

The IR imagery was digitized by the AGEMA scanner at 13 bits by an internal A/D converter. Due to a bug in the acquisition program, only the least significant six bits (i.e., the intensity was "folded" to six bits of intensity) were stored to hard disk. As a result of this error, the analyst had to subtract previous or subsequent images to reveal cloud details. Luckily, the dominant artifacts in the "folded" imagery were a result of internal reflections that remained constant and were completely eliminated by image subtraction. In addition, the image subtraction removed some of the elevation-dependent atmospheric radiance gradient. Interestingly, the "folded" and background-subtracted imagery revealed all of the ground cloud with a single intensity span. Normally, one can only view a portion of the 13 bits of intensity spanned by the ground cloud and the elevation-dependent atmospheric radiance. A downside to the image subtraction was that the exhaust cloud was in all imagery subsequent to launch. Therefore, the processed images can contain both positive and negative images of the ground cloud when subsequent imagery serves as background. By wise selection of the images, the positive and negative exhaust cloud images had minimal overlap and posed little difficulty for image interpretation.

Quantitative analysis of the IR imagery for the first 2.5 min after launch documented the cloud's rise rate, expansion rate, bearing, and speed, without recourse to other data. The "ground cloud" is defined as the lower and more concentrated portion of the rocket's exhaust cloud that can diffuse to the ground. The "launch column" or contrail is defined as the trail of the rapidly moving rocket that extends above the more spherical "ground cloud."

The T-0.70 h rawinsonde pre-launch meteorology data are documented in Appendix B and referenced in this section. Those rawinsonde wind data were used to run the "normal launch" REEDM predictions. The complete output for the T-0.70 h REEDM predictions is documented in Appendix A and referenced in this section.

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2.3 Field Deployment

2.3.1 Planning

The Aerospace Corporation's participants are listed in various teams below (members of the imaging teams for #B33 are indicated with asterisks):

Technology Operations
    Space and Environment Technology Center
        Surveillance Technology Department (STD)
            J. T. Knudtson, Director of STD
            B. P. Kasper* (Field Crew Team Leader) (Tower Site)
            G. N. Harper *   (UCS-4 Site)
            D. K. Stone* and J. T. Valero*   (UCS-2 Site)
            L. Foster*   (Press Site)
            R. S. Precious, Secretary of STD
    Space Launch Operations
        Systems Engineering Directorate
            Environmental Systems
                N. F. Dowling, Systems Director
                H. L. Lundblad*   (Tower Site)
        Eastern Range
            Systems Engineering Directorate
                D. R. Schulthess
                J. R. Ligda*   (Press Site)
                R. E. Reyes*   (UCS-4 Site)
                A. (Toni) Krell, Security

2.3.2 Equipment

The equipment at each site included all the hardware and software necessary to record and document the launch, to communicate between sites, and to supply backup power in case of an outage at the fixed power distribution points. The VIRIS consists of an array of three full and one backup (excluding the IR imager) cloud tracking systems and was designed and fabricated at the request of Space Launch Operations, Systems Engineering Directorate, at The Aerospace Corporation. Each full tracking system consists of coaligned visible and infrared (IR = 8–12 μm) imagers, mounted on an azimuth- and elevation-encoding tripod, with an associated data acquisition and display console. The combination of visible and IR imagers permits cloud tracking in both daylight and darkness. The unique capabilities built into the VCR hardware include digital insertion of imager azimuth (AZ), elevation (EL), time, and GPS location. The system electronics

is integrated in a single package, which has been ruggedized for field use. Pre-wiring of this package makes deployment of these imager systems straightforward, usually requiring less than 45 min for instrumentation at a site to become fully operational.

For the Titan IVB #B33 mission, the operators at each site set the FOV of the visible imager using the adjustable 10 to 110 mm electronic zoom lens. They also selected the best lens for the IR imager. All operators rotated the tripod head to keep the ground cloud within the FOV as it moved from the launch pad.

Table 1. Field of View (FOV) for Imagery Sites during #B33 Mission

Imagery Site	Imager Type (Visible or IR)	FOV(horizontal) (deg)	FOV(vertical) (deg)
(1) East of UCS-4	AGEMA Infrared	40.64	20.26
(2) Pond at Press Site	AGEMA Infrared	41.67	19.67
(3) UCS-2	AGEMA Infrared	technical difficulties	technical difficulties
(4) Tower 60691	AGEMA Infrared	40.85	20.86

All four imaging systems deployed for the Titan IVB #B33 mission were capable of total autonomy. Each VIRIS has an on-board differential-ready Xybion GPS receiver that can be used to document each imager's position with moderate spatial resolution. Typically, 35 m is the precision in the horizontal plane, and 100 m is the precision in the vertical plane. For the #B33 imagery sites, a Trimble differential GPS provided more accurate GPS data (2 m resolution) for each of the surveyed camera sites. Gasoline-powered AC generators (Honda Ex1000) are insurance against loss or absence of facility power. The Stirling cooler option for the AGEMA 900 series IR imager was chosen so that liquid nitrogen would not be required at the sites. Each unit is transportable in a standard utility wagon (e.g., Ford Explorer).

The AZ/EL angle encoder for all imager systems was calibrated using reference objects (e.g., SLC-40) within the field of view (FOV) of the imager. When reference objects are not part of the geodetic survey database, the GPS location uncertainty is the dominant term in the positional accuracy. Imager pixelation and operator error in edge detection contribute as well to the error in defining the cloud boundary. The 0.07° step-size in the tripod angle encoders is a third source of error. The analysis accuracy is determined either by the availability of optimal references for AZ/EL calibration or by the step size for the tripod angle encoder. Typically the VIRIS system provides 0.1° accuracy in both elevation and azimuth.

2.4   Processing of Imagery Data

The processing of the imagery data requires several transformations that are performed upon return to The Aerospace Corporation:

1. Digitizing frames of the visible imagery (i.e., daylight launches).

2. Measuring the pixel locations of the reference sites within each image (i.e., FOV and angular calibration).

3. Measuring the pixel locations of cloud features in digitized images.

4. Converting pixel locations to azimuth and elevation readings.

5. Calculating cloud characteristics (i.e., position in Cartesian coordinates relative to the launch pad).

The processing requires the use of specialized hardware and software. When used, visible images of the cloud are digitized at precise times, beginning with time intervals of 15 s, then 30 s, then 1 min as the cloud evolves. The AGEMA 900 IR imagers produce digital images every 15 s in the field. A set of digitized images is selected for specific times following the launch and from each of the available imagery sites. Time, AZ, and EL are tabulated for each set. A setup file is created for each of these sets, containing all relevant information necessary to compute the cloud geometry using the imagery. The Aerospace program's **PLMTRACK** and **PLMVOL** are run to digitize the x, y, and z coordinates of cloud features and to estimate the volume of the exhaust cloud, respectively. These programs report the x and y coordinates relative to the launch pad and the z coordinate as height above MSL. We converted the height MSL to height above ground level (AGL) by subtracting the 7 m MSL for the height of SLC-40. This allows direct comparison of the imagery-derived data to REEDM's output.

PLMTRACK is a software program developed and maintained by Brian P. Kasper in the Environmental Monitoring and Technology Department (EMTD) of The Aerospace Corporation. It is designed to analyze pairs of cloud images synchronized in time. In various versions,[1] **PLMTRACK** has used the linear and rigorous (i.e., trigonometric) methods of interpreting pixels as AZ and EL and vice versa. **PLMTRACK** provides an absolute method of triangulating the position of the abort cloud without making any assumptions regarding the position of the abort cloud. This report presents the rigorous trigonometric **PLMTRACK** results.

When using the **PLMTRACK Line Method**, the operator selects the location of a particular cloud feature in the images from the two imager sites by moving a screen pointer to the desired feature in each image and clicking a mouse button. **PLMTRACK** then calculates the point of nearest approach to the two rays defined by the selected points. The three-dimensional location of this feature is then written to a data file.

Another implementation of **PLMTRACK** is illustrated in Figure 1. When using the **PLMTRACK Box Method**, the operator draws a rectangle about a cloud feature in the images from the two imager sites by moving a screen pointer to the extreme corners of the rectangles and clicking a mouse button. **PLMTRACK** then calculates the closest approach for various rays, as illustrated in Figure 1 and described below. The top of the cloud is defined by rays determining T1 and T2 (i.e., T1 x T2); the bottom is determined by rays defining B1 and B2 (i.e., B1 x B2); and the middle is defined by the geometric mean of top and bottom (i.e., M1 x M2). To define the "faces" of the "box," the points of closest approach for ray M1 with L2 and R2 (the left and right tangents to the cloud from Imager 2) are defined (i.e., M1 x L2 and M1 x R2). A similar procedure is used to define the points of closest approach for M2 with L1 and R1, yielding M2 x R1 and M2 x L1. In addition to the centers of the faces of the "box," the intersects of the left and right rays document the four vertices for the XY polygon. Thus, eleven points are defined for the six-faced "box" surrounding the cloud (a point in the center of each of the six

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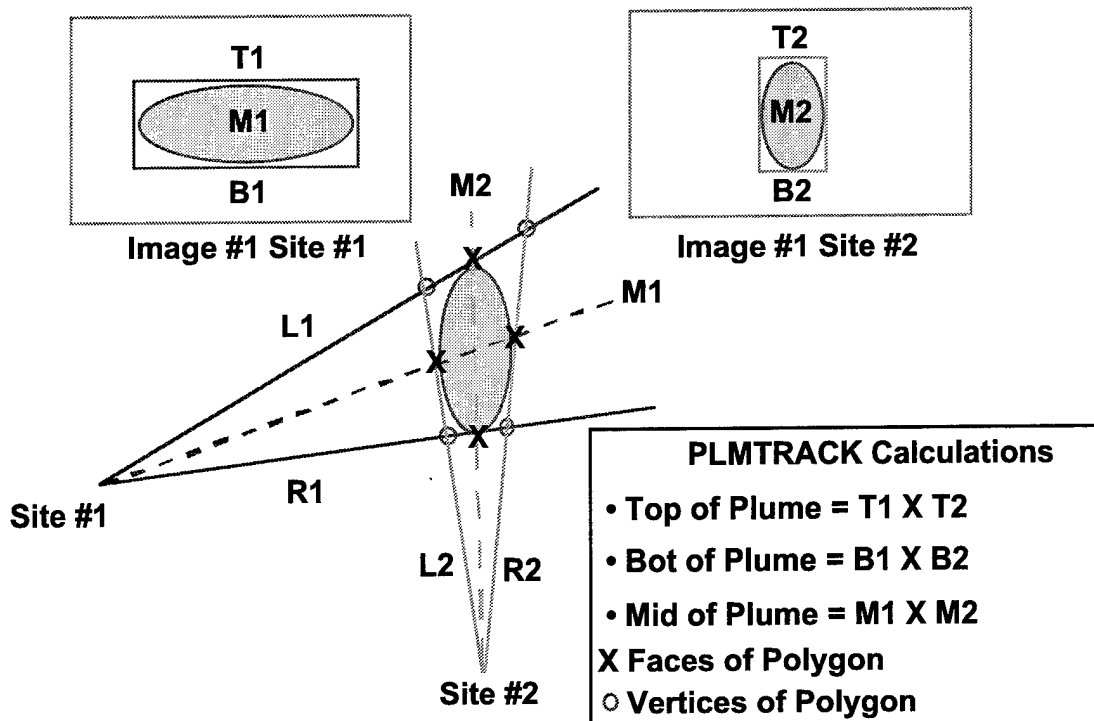
Figure 1. Implementation of the PLMTRACK "box" method with two imagers.

faces, four vertices for the XY polygon, plus a middle point for the "box"). These eleven sets of x, y, and z coordinates are written to a file.

When three imagers are viewing the cloud simultaneously, a six-sided polygon method (documented in Figure 2) has been employed as a way to document the maximum extent of the cloud (i.e., a ground-plane projection) for each set of images. With three imagers, there is a triply redundant determination of the top, middle, and bottom of the cloud by **PLMTRACK**. The horizontal extent of the cloud is determined by defining the rays from each imager that are tangential to the widest part of the cloud as seen from that site. Projection of these extreme rays for each imager on the x-y ground plane forms a polygon that bounds all material in the cloud at all

altitudes, as shown in Figure 2. Thus, when an aircraft is flown against the ground cloud (i.e., #K15, #K16, #K22, and #K23 missions), one expects to see aircraft HCl sampling "hits" fall within this polygon, regardless of the sampling altitude. When the polygon area is combined with the mean cloud height (i.e., the difference between the top and the bottom of the cloud), one can obtain an upper bound for cloud volume. As illustrated in Figure 2 (a ground projection of the cloud's extent), the shaded area within the polygon documents the extent of the cloud derived from **PLMVOL** analysis. There is excellent agreement between **PLMTRACK** and **PLMVOL** results.

The utility of the polygon method has been documented in a previous report[2] for the #K23 mission. In that report, the polygons from imagery were correlated with aircraft's HCl measurements

10000

UCS-04

8000

6000

4000

Press

2000

0

Distance in Meters N/S of SLC-40

-2000

-4000

UCS-02

-6000

-8000

Tower

-10000

-7000   -6000   -5000   -4000   -3000   -2000   -1000   0   1000

Distance in Meters E/W of SLC-40
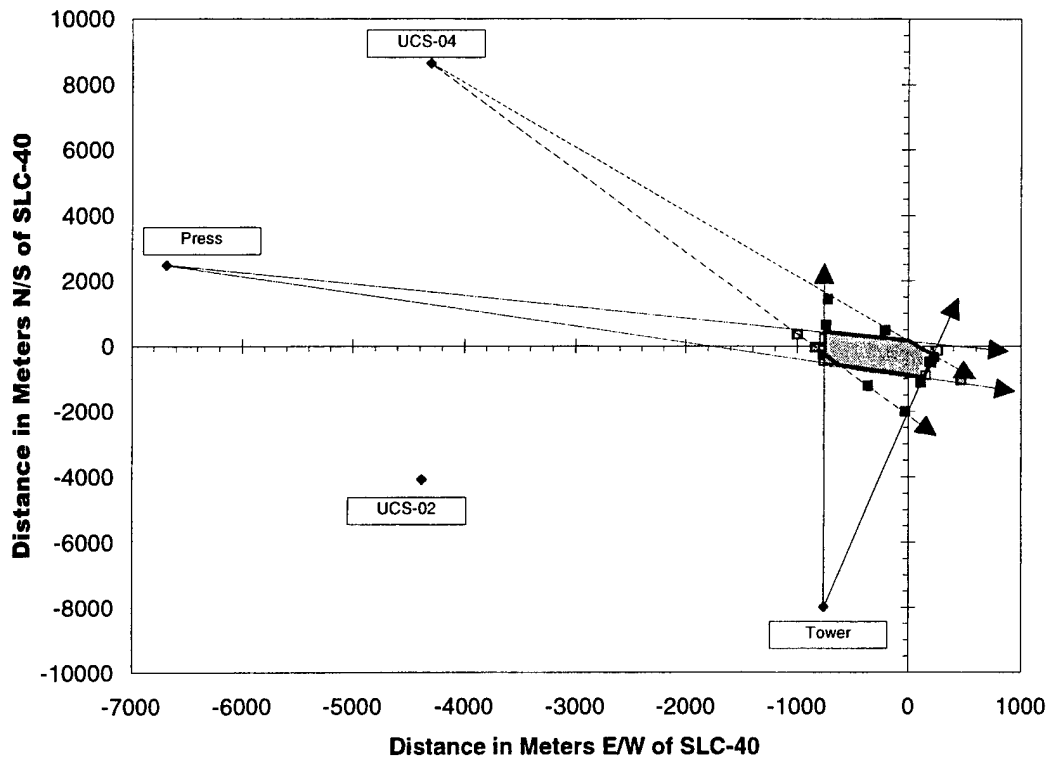
Figure 2.   Comparison of the #B33 cloud extent derived from the PLMTRACK polygon
analysis and from the PLMVOL analysis (i.e., shaded area within PLMTRACK
polygon). The imager positions and rays are actual #B33 data for T+01:30 (mm:ss)
after launch.

of cloud dimensions and average HCl concentrations for the Titan IVA #K23 launch cloud.
After correcting for Geomet time response, the #K23 dataset established that HCl concentrations
detectable by an aircraft-based Geomet total HCl detector were mostly contained by the six-sided
polygon areas for the first 20 min after launch. The #K23 data established that the imagery-
derived position of the visible cloud correlates with the measurable HCl concentrations. A similar
treatment is possible with the #B33 imagery (without aircraft data) and allows a mapping of the
growth and position of the cloud over time.

Brian P. Kasper also created and maintains the **PLMVOL** program at The Aerospace Corpora-
tion. **PLMVOL** provides a convenient way of triangulating all of the volume elements that could
be occupied by an object using imagery from two (or more) sites. Like **PLMTRACK**,
PLMVOL has used the linear and rigorous (i.e., trigonometric) methods[1] of interpreting pixels as
AZ and EL and vice versa. For the #B33 mission, the rigorous trigonometric **PLMVOL** algo-
rithm provided an absolute method of triangulating the position and volume of the abort cloud.
The analyst outlined the edge of the abort cloud in images acquired simultaneously from the
three sites. **PLMVOL** determined all of the pixels that were within the outlines in each image and
projected the rays for all of those pixels into space. **PLMVOL** defined volume elements in space
and determined which volume elements were intercepted by the projected rays from all imagery

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sites. These intersected volume elements could be occupied by the abort cloud. **PLMVOL** reports the x,y,z coordinates for all "occupied" volume elements. The coordinates are relative to a reference (i.e., SLC-40 for x and y and mean sea level for z). **PLMVOL** calculates the total volume (i.e., sum of all occupied volume elements), the sphere-equivalent radius, and the mean altitude for the abort cloud (i.e., mean position of all occupied volume elements). For facile comparison to REEDM, this report uses altitude relative to SLC-40 pad (i.e., AGL) rather than MSL in all plots.

The **PLMVOL** approach is illustrated by Figure 3 for simultaneous images of the Titan IV #K23 normal launch cloud from three sites. We used the #K23 images to illustrate **PLMVOL** since that cloud had a more complicated shape. The **PLMVOL**-derived reconstructed cloud is shown from a perspective similar to the middle image in Figure 3, but can be viewed from any perspective.

PLMVOL analysis of the #B33 imagery was possible between 0.25 and 2.5 min after the launch. There is excellent agreement between the **PLMVOL** and **PLMTRACK** results. Both **PLMTRACK** and **PLMVOL** provide ground track, rise rate, and extent data; PLMVOL, in addition, provides volumetric data and extent as a function of altitude. Even though low-lying atmospheric clouds blocked the view of the top of the cloud by 1.5 min after launch, **PLMVOL** analysis tracked the bottom of the cloud until 2.5 min after launch.
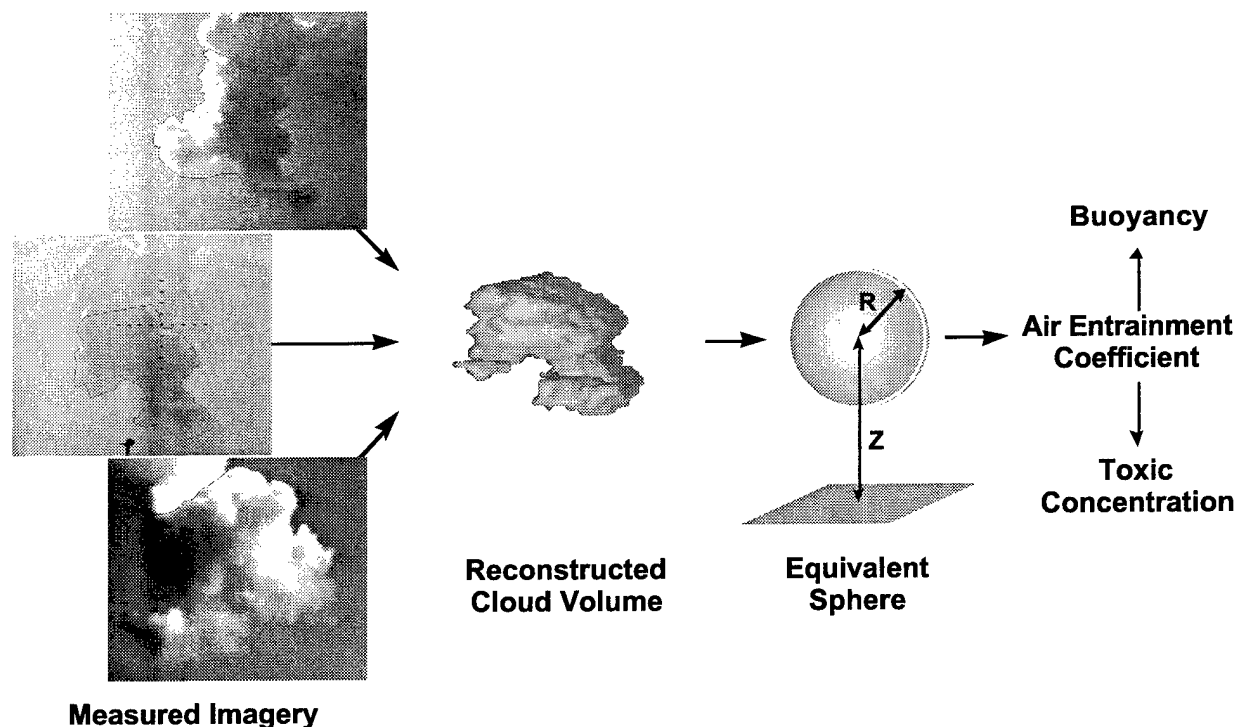
Figure 3. PLMVOL approach illustrated by Titan IV #K23 ground cloud images.

2.5   Results and Discussion

2.5.1   Correlation of Ground Cloud Bearing with Wind Direction

Figure 4 presents the imagery-derived cloud bearing and the T-0.70 h REEDM-predicted ground cloud bearing as arrows originating from the launch pad and as text. The darkly bordered text box and wide dark arrow are imagery data while the lightly bordered text box and the medium-wide arrow are the REEDM prediction. Figure 4 also documents the rawinsonde wind directions at the REEDM-predicted height for the top, middle, and bottom of the stabilized ground cloud. The rawinsonde wind bearings are illustrated with narrow arrows originating from the rawinsonde release site and in a narrowly bordered text box. Lastly, Figure 4 documents the locations of SLC-40 launch pad, the rawinsonde release site, and the four imager sites (UCS-4, Press, UCS-2, and Tower) that were operated by The Aerospace Corporation for the #B33 mission. All directions are reported in rawinsonde convention [defined fully in Subsection 2.5.4]. Briefly, the arrows indicate the direction the cloud would move for a wind coming from the reported angle (clockwise from north).

As illustrated in Figure 4, there is agreement between the imagery-derived cloud bearing, the REEDM-predicted cloud bearing, and the rawinsonde wind directions at the equivalent heights.
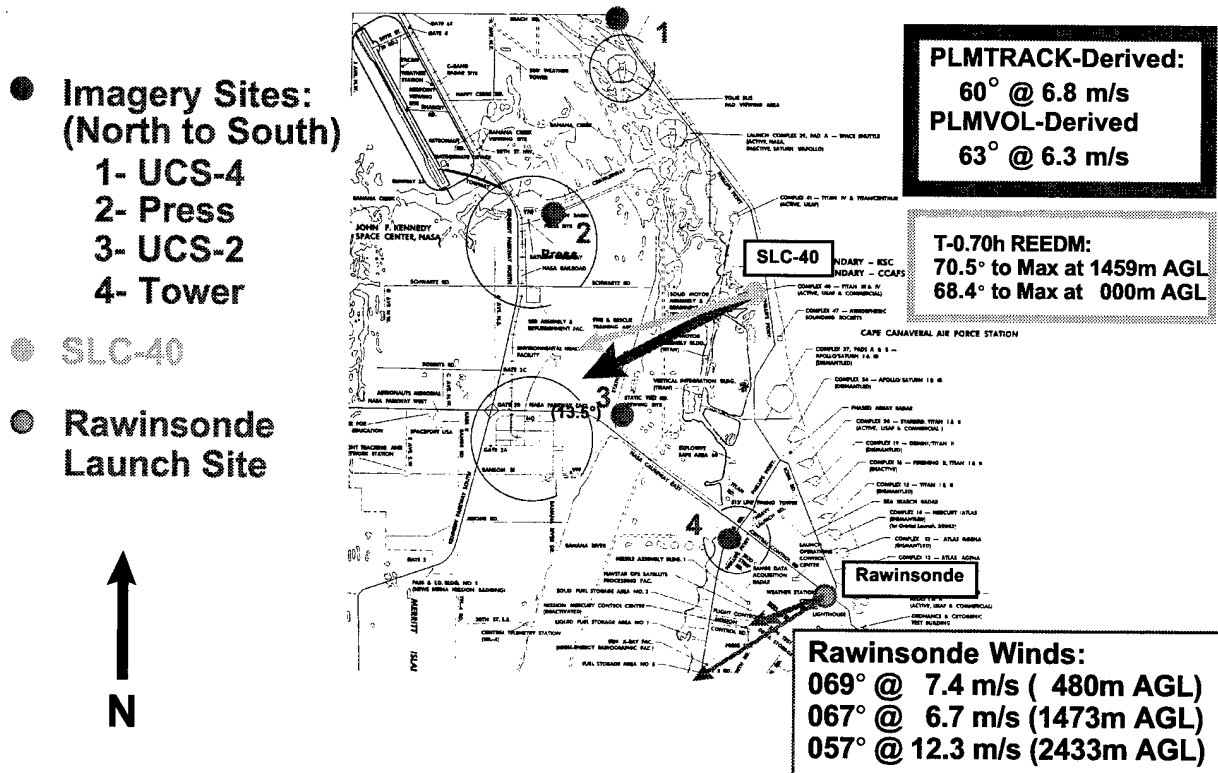
Figure 4. Map documenting the imagery sites, the rawinsonde release site, the #B33 ground cloud's bearing (derived from IR imagery), the T-0.70 h REEDM prediction for the ground cloud's bearing (at stabilization height), and the 08:03 GMT (T-0.70 h) rawinsonde wind directions at the predicted cloud stabilization heights (bottom, middle and top).

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The quantitative imagery documented a cloud bearing of 63° by **PLMVOL** analysis (i.e., wide arrow in Figure 4) and 60° by **PLMTRACK** analysis during the first 1.5 min after launch. REEDM predicted a shift in cloud bearing during rise: 42° at 13.4 m altitude to 68° at 785 m altitude. REEDM version 7.08 predicted the cloud's bearing as 70.5° (i.e., medium arrow in Figure 4) to the maximum cloud concentration at the predicted stabilization height (i.e., 1459 m AGL). This is almost identical to the predicted cloud bearing of 68.4° to the maximum cloud concentration at ground level. After stabilization, REEDM predicts a 68.5° cloud bearing at 1459 m AGL (based upon the average wind in the first mixing layer). At ground level, the cloud's predicted bearing was 68.13° after stabilization. There are negligible differences in the predicted bearings at the stabilization height and at ground level due to almost negligible wind shear between the stabilization height and the ground. This is consistent with the imagery and with the T-0.7 h rawinsonde data. Figure 4 also presents the rawinsonde-derived wind directions (69°, 67°, and 57°) associated with the rawinsonde sounding heights (480, 1473, and 2433 m AGL) nearest the bottom, middle, and top of the stabilized ground cloud, respectively. These wind directions are from the T-0.7 h rawinsonde data and at the indicated sounding heights closest to the REEDM-predicted stabilization heights of 480, 1459, and 2433 m AGL for the bottom, middle, and top of the ground cloud, respectively. Since the view of the cloud was obstructed by low-lying atmospheric clouds, the imagery could not measure the stabilization height for the cloud. However, the imagery documented a linear increase in height with time for the bottom of the cloud until 2.5 min after launch and through 514 m AGL. The linear increase suggests a stabilization height greater than 514 m AGL.

Figure 5 includes raw IR images for T+0 s and T+45 s as recorded from UCS-4 site. These raw images have the intensity "folded" to only 6 bits and reveal artifacts due to internal reflections within the lens and imager. In spite of this complication, it is possible to see the ground cloud and launch column in the lower image (i.e., T = 45 s). We were able to eliminate the artifacts by subtracting the T+0 s image from the T+45 s image. This background-subtracted image is included as the upper left image in Figure 6. The other two images in Figure 6 are the background-subtracted T+45 s imagery from Tower Site (i.e., upper right image) and from Press Site (i.e., lower image). In all three of the images in Figure 6, the ground cloud is the broader low-altitude portion of the exhaust and is easily distinguishable from the thinner contrail. The northern (USC-4) and southern (Tower) perspectives document asymmetry in the cloud's shape with a lobe to the east (i.e., left from UCS-4 and right from Tower perspectives). This outcropping of exhaust resulted from ejection of exhaust to the east from the exhaust duct on SLC-40 pad. The upper portion of each image documents the low-lying atmospheric clouds while the lower portion of each image documents the terrain between the camera site and the launch pad. For Press Site, there is a reflection of the ground cloud observable in the pond between the Press Site and SLC-40. The wide intensity bands apparent in the processed imagery from Press Site resulted from differences in camera pointing elevation between the cloud image and the background image. A narrower band due to folding of the intensity at a single elevation is evident in the UCS-4 processed imagery.
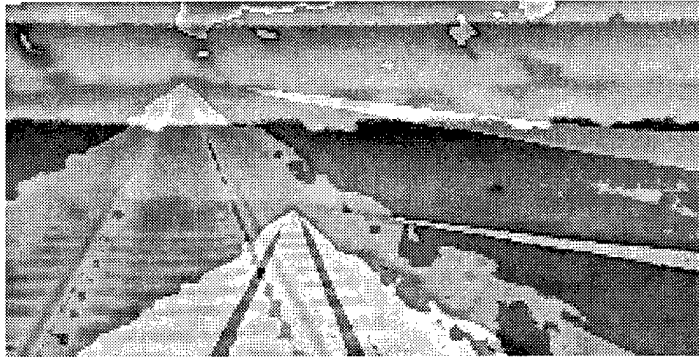
Real and Reflected Images of Beach Road, the Rail Road Tracks, and the Sky at T=0s (No Launch Cloud)

Real and Reflected Images of Beach Road, the Rail Road Tracks, and the Sky at T=45s (With Launch Cloud)
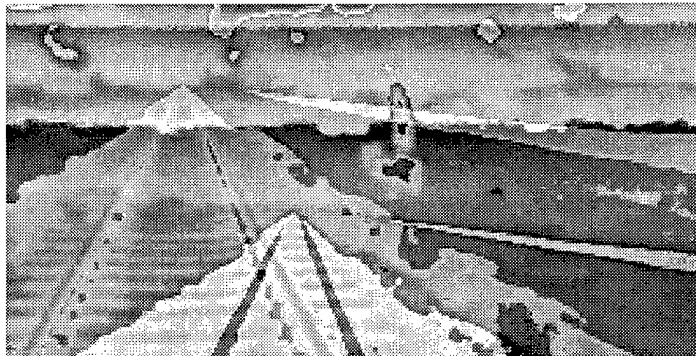
Figure 5. Raw imagery from UCS-4 Site at 08:43:00 and 08:43:45 GMT (T = 0 s and T = 45 s).
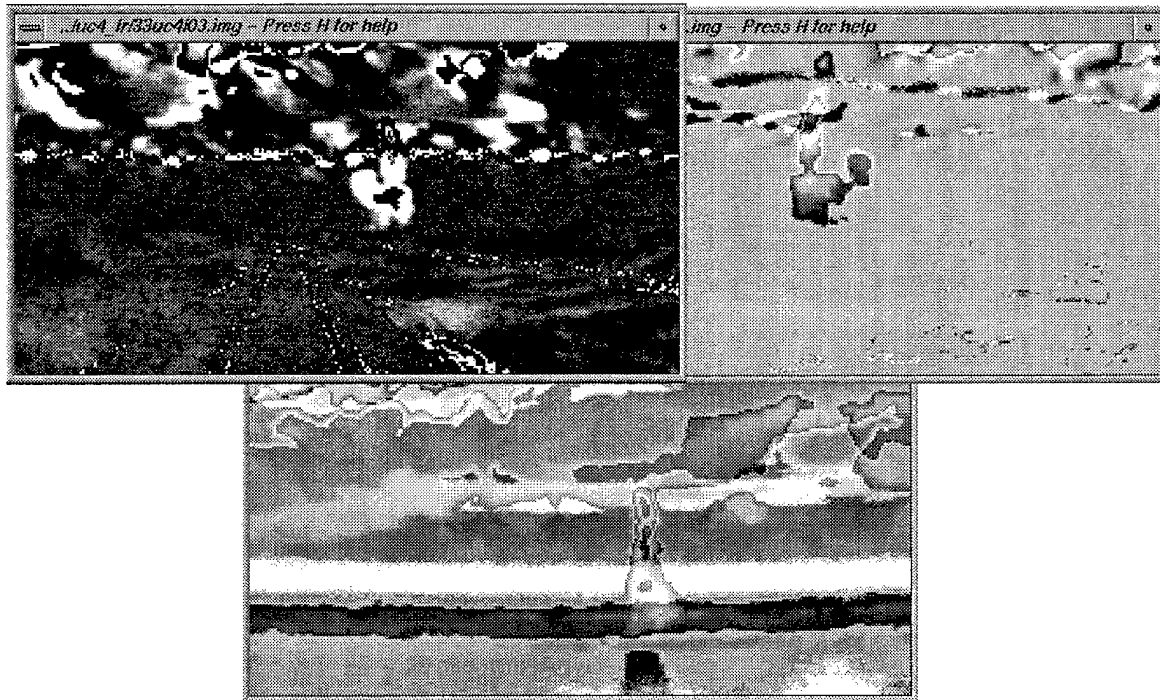
Figure 6. Processed imagery (T = +45 s) from UCS-4, Tower, and Press Sites (clockwise).

Figures 7 through 9 are exactly the same background-subtracted images shown in Figure 6 with the addition of an outline about the ground cloud (i.e., in Figure 7), **PLMVOL**'s filling of the outline (i.e., in Figure 8), and **PLMVOL**'s reflection from the intersected volume elements (i.e., in Figure 9). It is apparent from review of Figures 6 through 9 that **PLMVOL** correctly identified the rays within the outline (i.e., filled the outline) and that **PLMVOL** correctly identified intersected volume elements (i.e., the reflected rays filled the cloud outline). Therefore, these images document a good calibration of the imagery. If the calibration were bad, **PLMVOL**'s "reflected" rays would not fill the cloud outline.
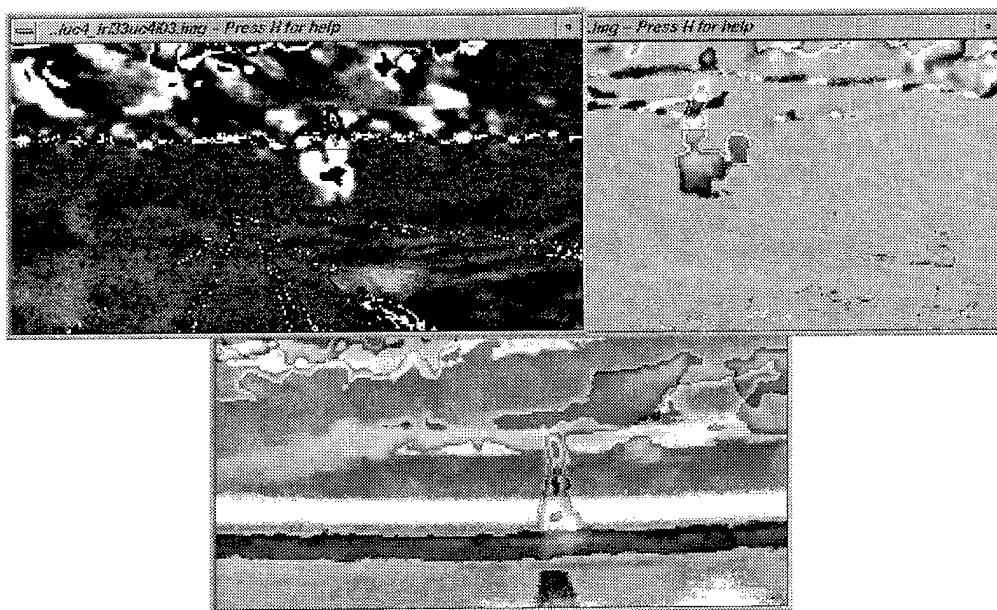
Figure 7. "Outlined" cloud (T = +45 s) from UCS-4, Tower, and Press Sites (clockwise).
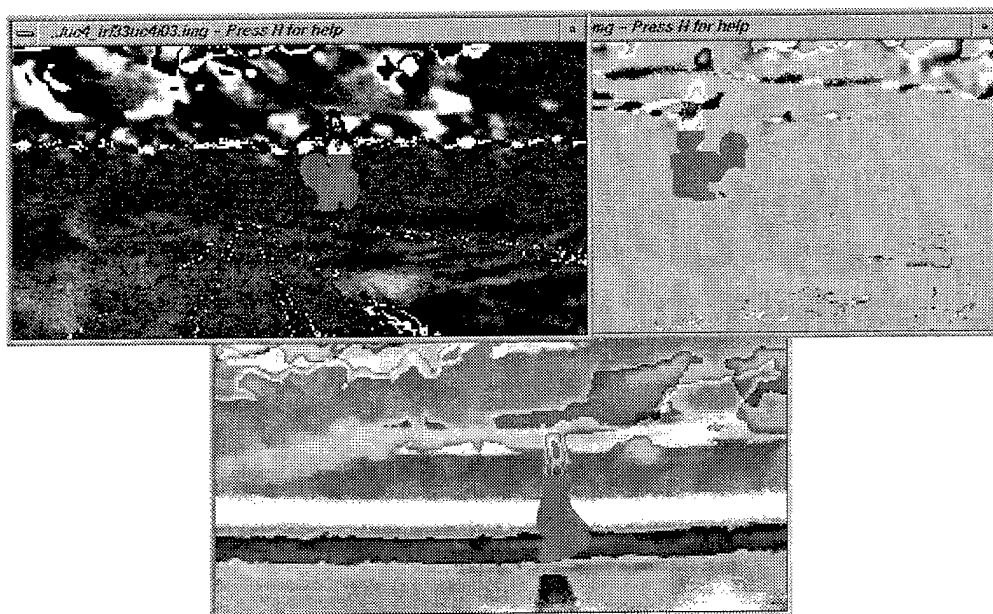
Figure 8. "Filled" cloud (T = +45 s) from UCS-4, Tower, and Press Sites (clockwise).

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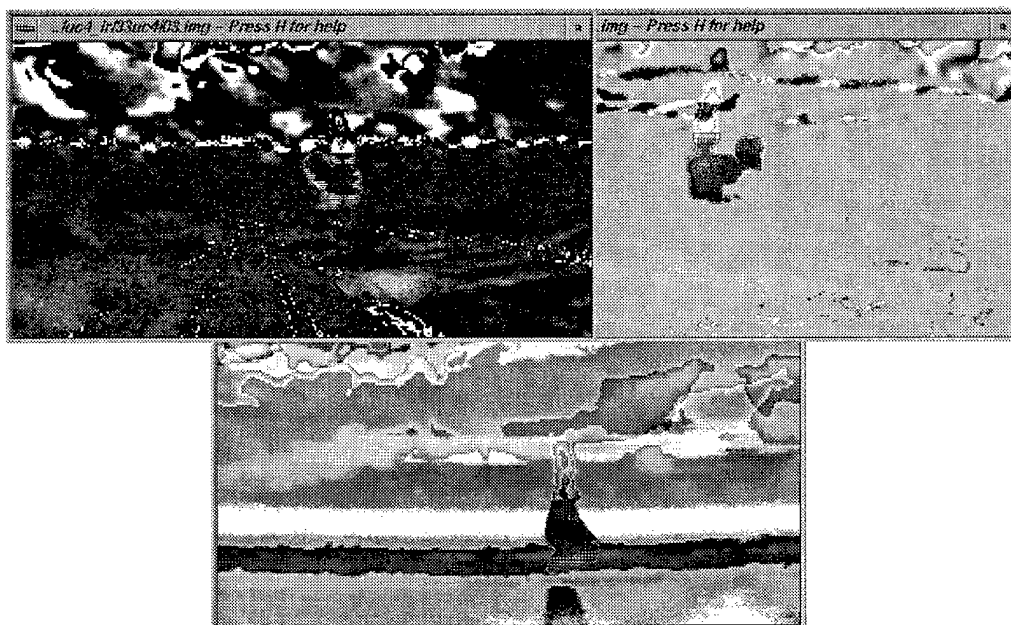
Figure 9. "Reflected" cloud (T = +45 s) from UCS-4, Tower, and Press Sites (clockwise).

2.5.2   Cloud Rise Times and Stabilization Heights

Figures 10 through 12 present the imagery-derived time-dependent altitude for the "bottom," "middle," and "top" of the ground cloud based upon **PLMTRACK** analysis (upper plots) and **PLMVOL** analysis (lower plots). In these plots, all data are plotted as height in meters above SLC-40 (i.e., m Above Ground Level). The analyst used the **PLMTRACK Box Method** separately for each of three image pairs from the three sites. Symbols identify the image-pairs used to track the cloud as defined in Table 2. For clarity, these plots include a linear least-squares fit to the combined data (i.e., all data independent of the image pairing). **PLMTRACK** analysis ended for the top and middle of the cloud when the top of the cloud was lost into the low-lying atmospheric clouds at times after 1.5 min. It is apparent from the linear increase in altitude with time that the cloud had not stabilized by 1.5 min after launch. The bottom was tracked by **PLMTRACK** until 1.75 min. The analyst used **PLMVOL** to process imagery from all three sites simultaneously. Therefore, the lower plots in Figures 10 through 12 report only one result for each set of images. **PLMVOL** analysis followed the bottom of the cloud (i.e., lower plot in Figure 10) until 2.50 min after launch and documented a linear increase in height with time from 0.75 min through 2.5 min (i.e., through 514 m AGL). These data document that the stabilization height is above REEDM's prediction of 480 m AGL for the bottom of the cloud. Comparison of the upper to lower plots in Figures 10 through 12 reveals excellent agreement between the **PLMTRACK** and **PLMVOL** results.

Table 2. Labels Used to Identify Imagery-Pairs used by PLMTRACK

Label	Imagery Site 1	Imagery Site 2
4ipi	UCS-4 INFRARED	PRESS INFRARED
4iti	UCS-4 INFRARED	TOWER INFRARED
piti	PRESS INFRARED	TOWER INFRARED

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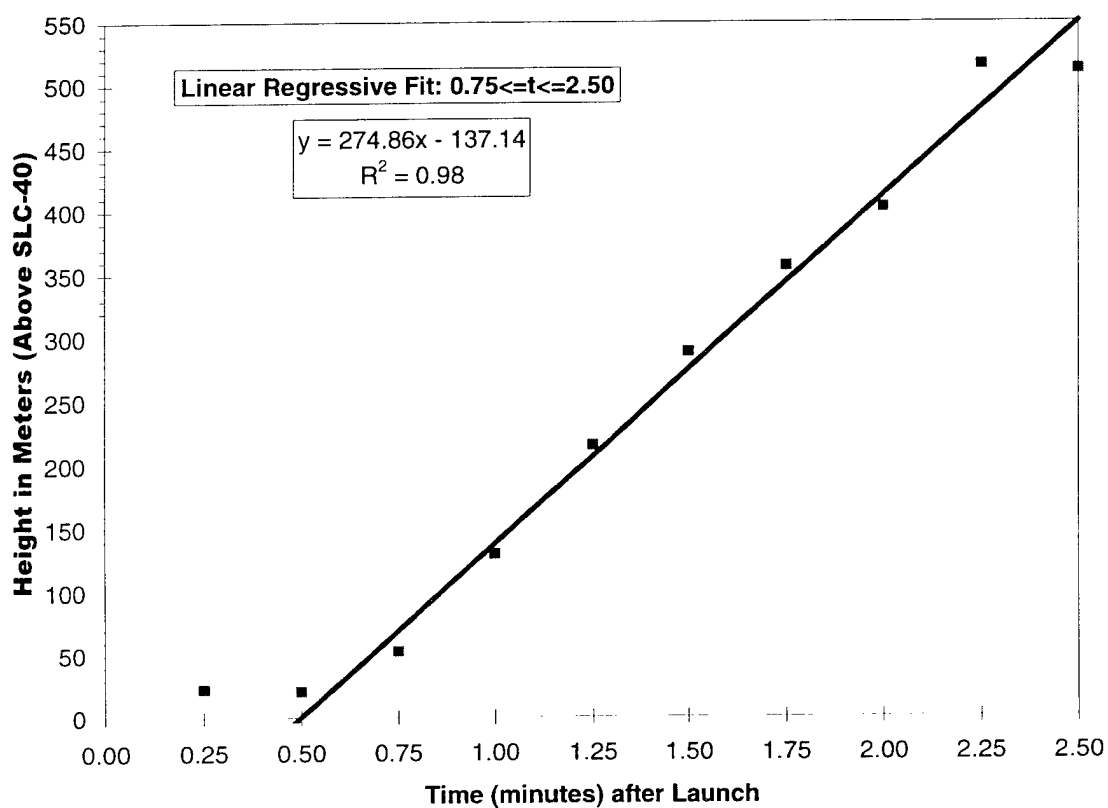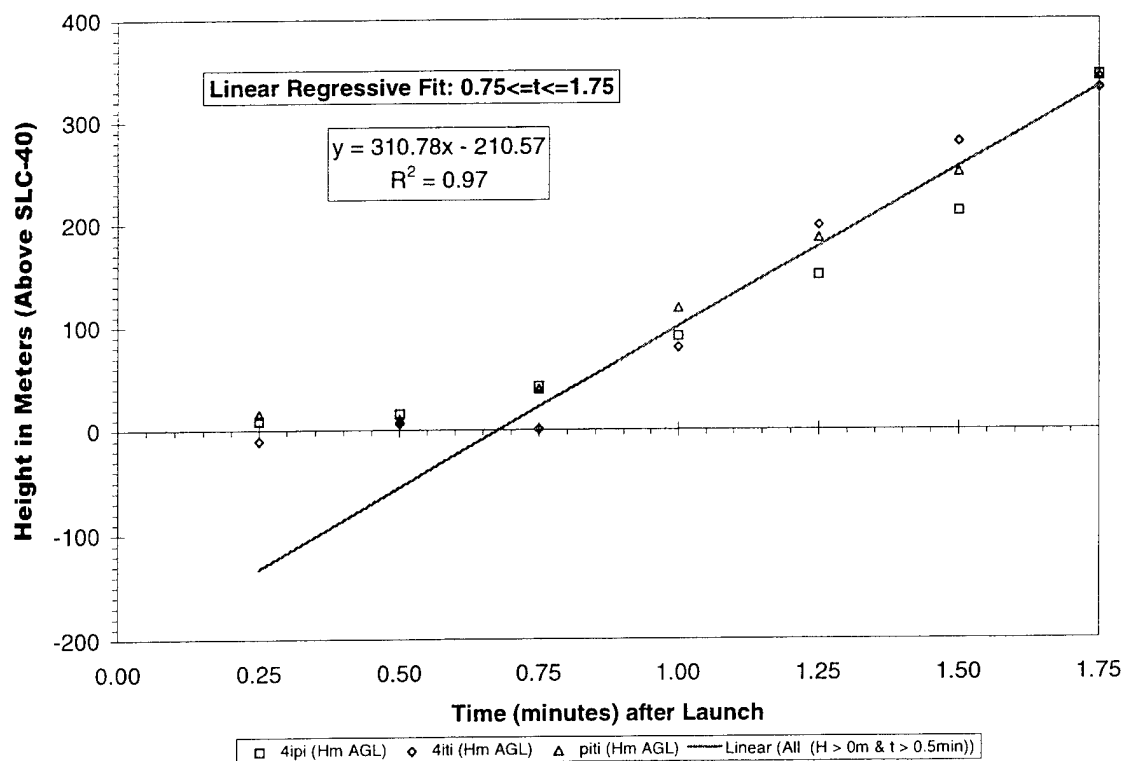
Figure 10. Cloud rise for the bottom of the #B33 cloud (PLMTRACK upper and PLMVOL lower).

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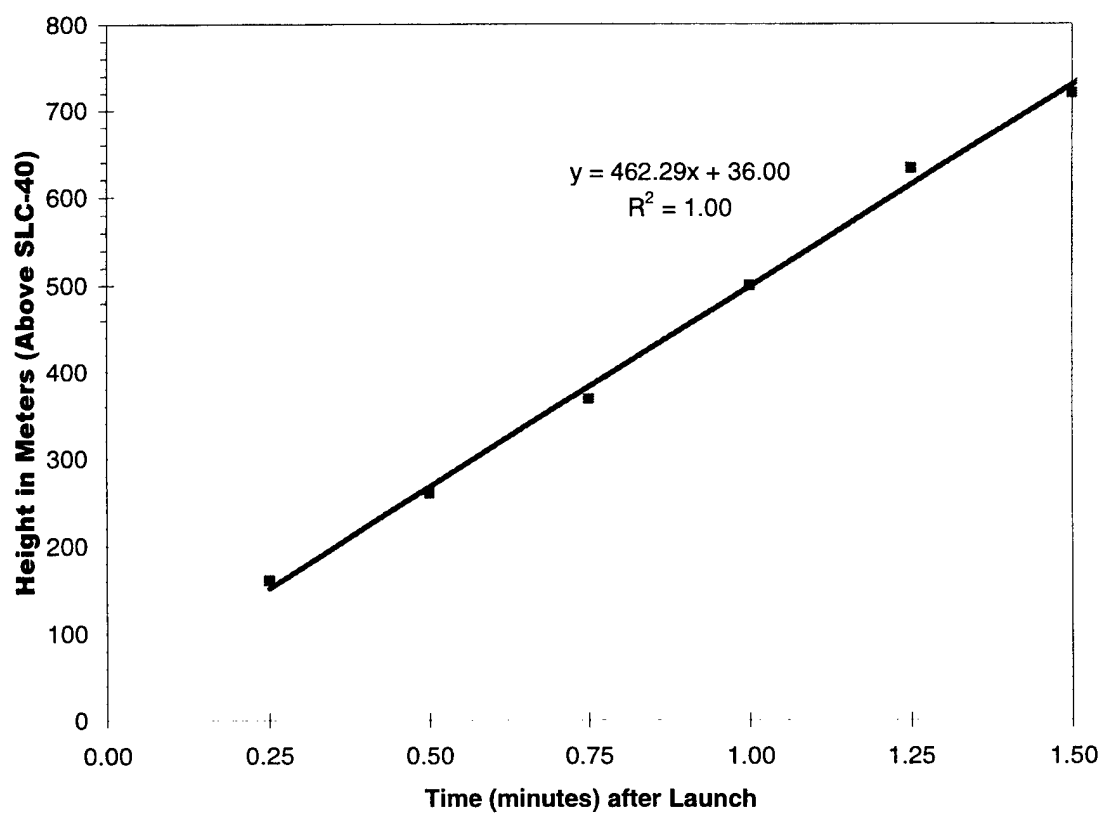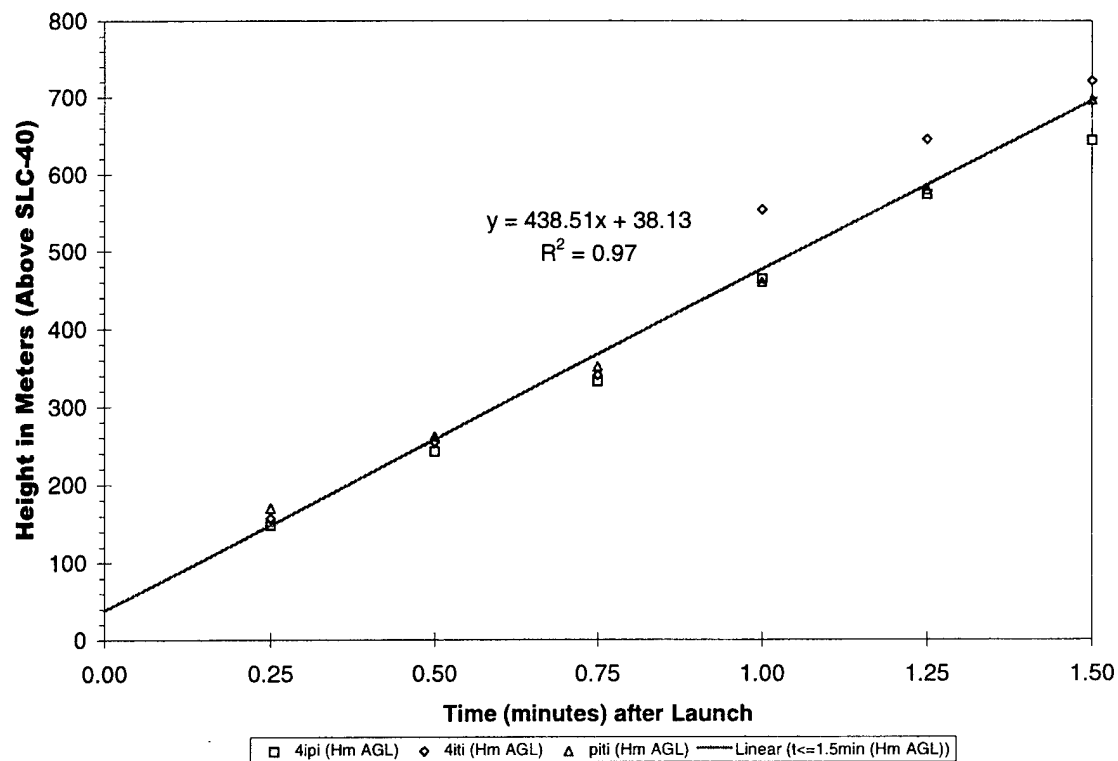
Figure 11. Cloud rise for the middle of the #B33 cloud (PLMTRACK upper and PLMVOL lower).
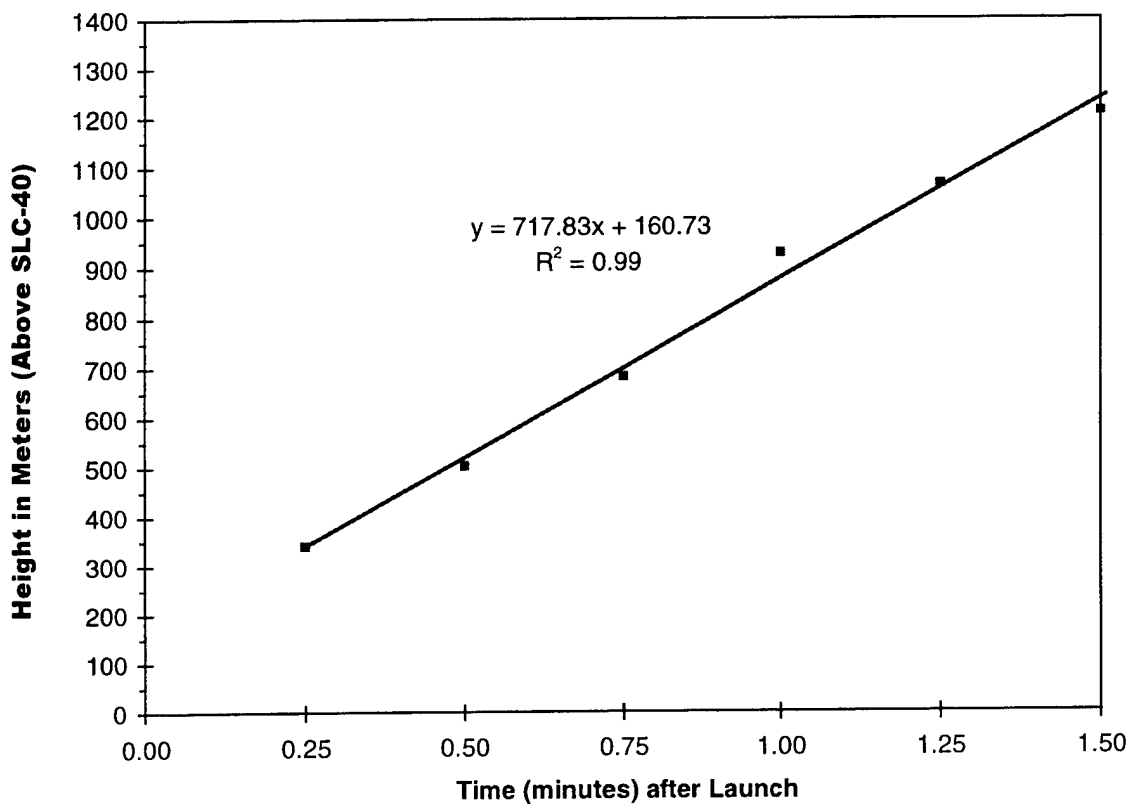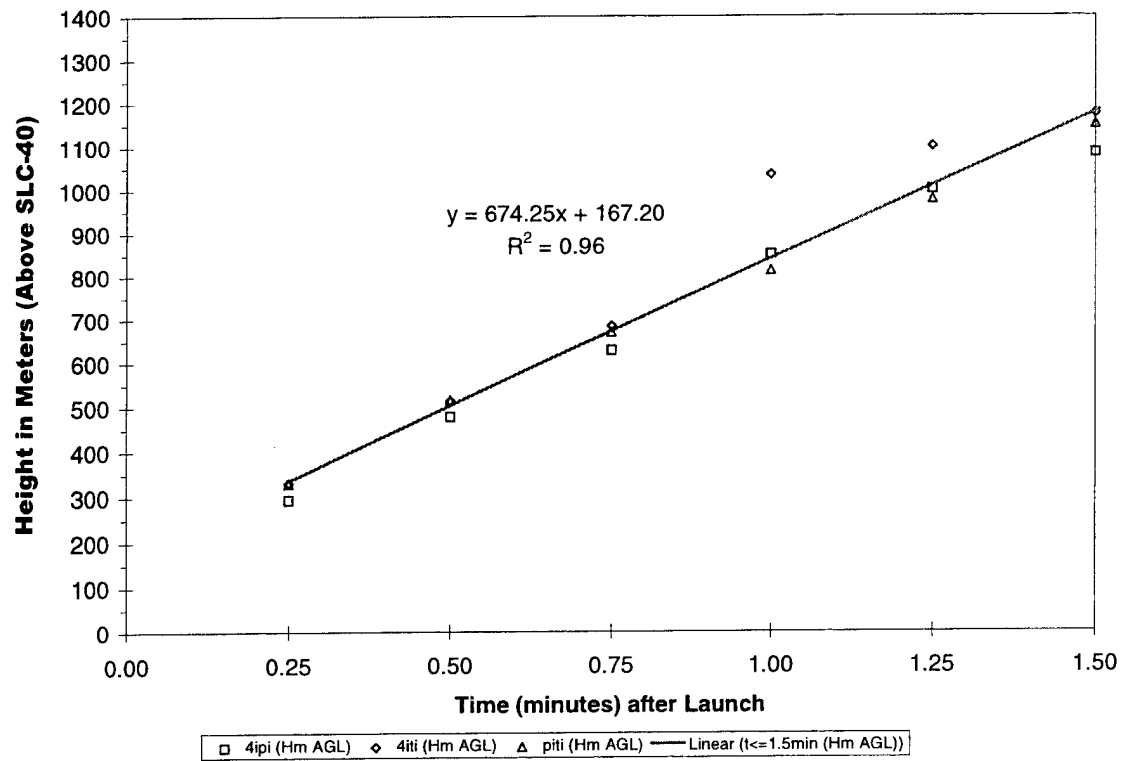
Figure 12. Cloud rise for the top of the #B33 cloud (PLMTRACK upper and PLMVOL lower).

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The variances (R^2) of the fits to the data indicate the quality of the fits. A polynomial fit is used when the cloud is tracked through stabilization. A polynomial fit is a convenient method to permit the representation of cloud overshoot and subsequent damped oscillation around the stabilization height. To be consistent with REEDM, stabilization time and height refer to the first maximum in polynomial fits. REEDM predicts that the cloud goes through damped oscillatory motion with a period of $2\pi/S^{1/2}$, where S is the static stability parameter [Ref. 1, Eq. (7)].[3] Sensitivity of REEDM predictions to input parameters has been examined by Womack.[4] Unfortunately, the imagery could not document the stabilization of the #B33 cloud due to low-lying atmospheric clouds.

2.5.3 Comparison of REEDM Prediction to Imagery Data—Rise Rate

Figure 13 presents the **PLMTRACK**-derived (i.e., upper plot) and the **PLMVOL**-derived (i.e., lower plot) heights for the ground cloud's top, middle, and bottom plotted as a function of time following the launch. For comparison, Figure 13 includes the predicted curve for the middle of the cloud based upon the T-0.7 h REEDM modeling run (Appendix A). There is excellent agreement between the **PLMTRACK** and the **PLMVOL** results. It is apparent that the imagery-derived altitudes for the bottom, middle, and top of the cloud follow a linear increase with time up to 1.5 min when the view of the top of the ground cloud is obstructed by the low-lying atmospheric clouds. In contrast, the REEDM prediction has significant curvature (i.e., at least a second-order function) between 0.5 and 1.5 min. The imagery data documents a 37-m extrapolated initial height for the middle (i.e., center) of the cloud at zero time while REEDM uses zero as the initial height of the cloud center.

2.5.4 Comparison of REEDM Prediction to Imagery Data—Bearing and Speed

Figures 14 and 15 document the imagery-derived cloud bearing and speed, respectively. In each figure, the upper plot is derived from **PLMTRACK** analysis while the lower plot is derived from **PLMVOL** analysis. The **PLMTRACK** analysis documents the movement of the middle of the cloud while the **PLMVOL** analysis documents the movement of the bottom and the center of the cloud. The middle is the average between the top and bottom and between the left and right sides of the **PLMTRACK** box. The **PLMVOL** "center" is a weighted average based upon the locations of all intersected (i.e., "occupied") volume elements reported by **PLMVOL**. In spite of the differences between the two methods, there is excellent agreement between the upper and lower plots.

In this report, the angles conform to the convention of rawinsonde wind vectors (the angle from which the wind originates that would push the cloud into its imaged position). Thus, the angles are related by

$$\vartheta = 180 + \Phi, \tag{1}$$

where ϑ is the equivalent rawinsonde wind angle, and Φ is the measured polar angle of the cloud relative to SLC-40 and clockwise of true north. For example, when the cloud is due east of SLC-40, Φ is 90°, and ϑ is 270°.
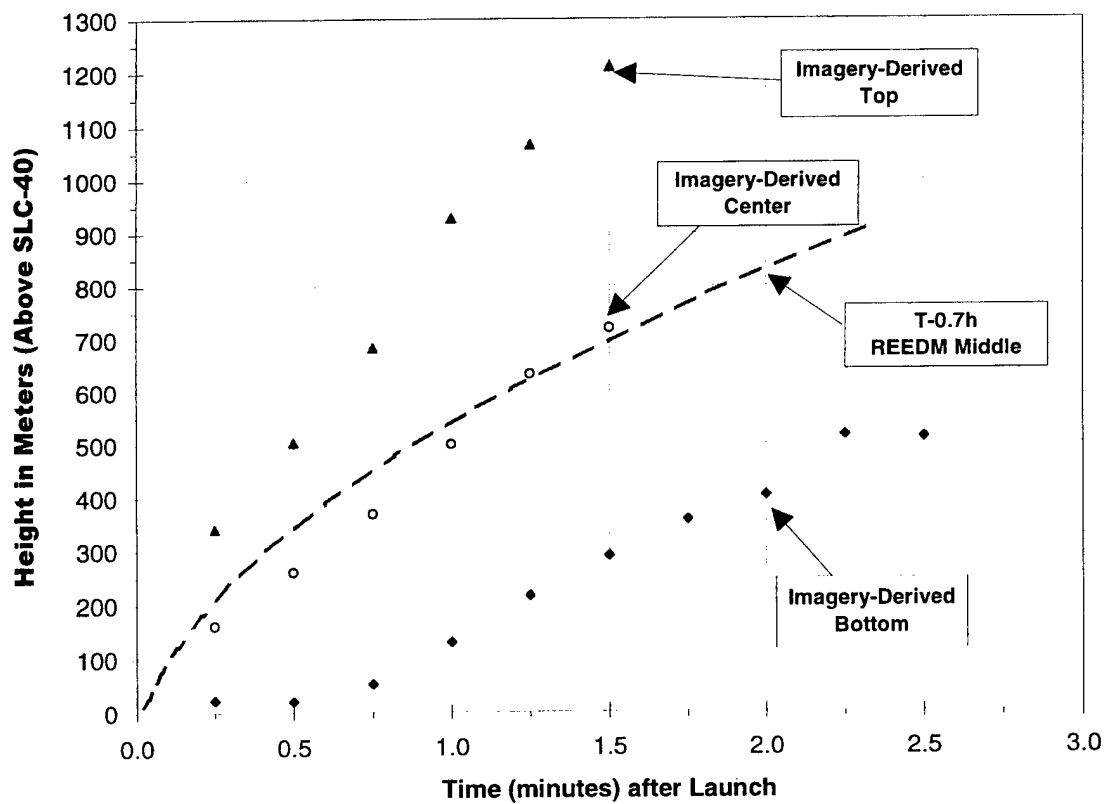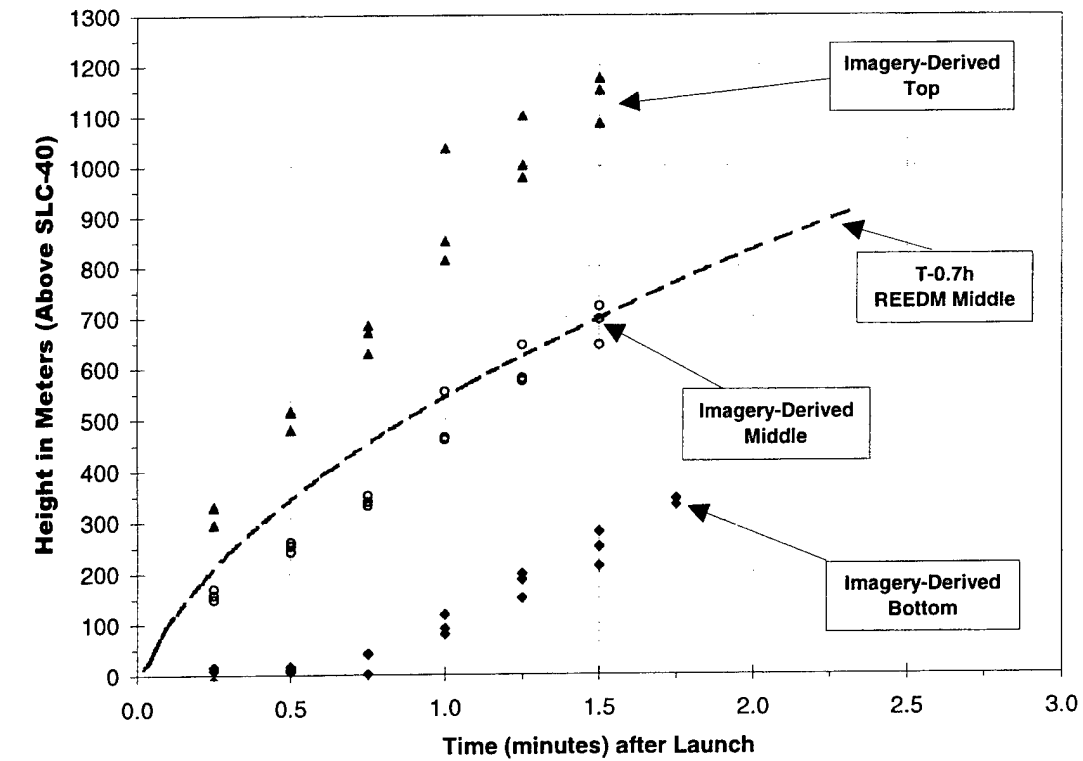
Figure 13. Predicted versus measured rise curves (PLMTRACK upper and PLMVOL lower).

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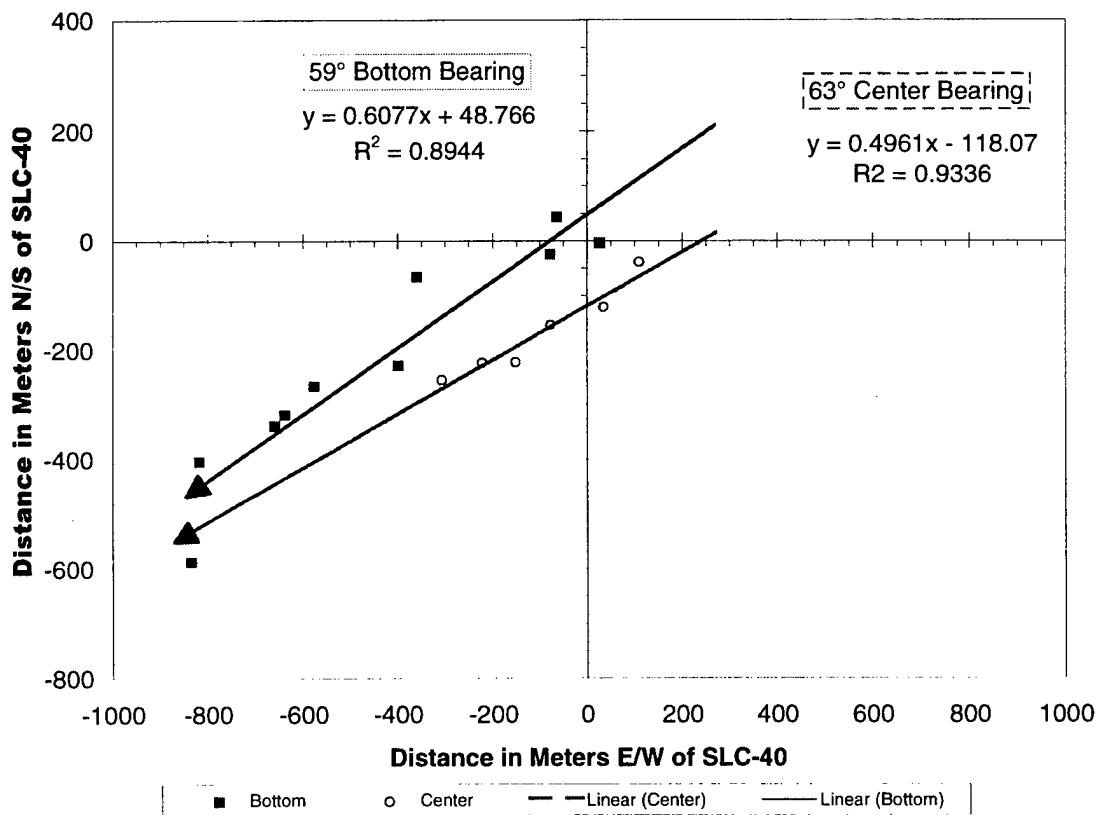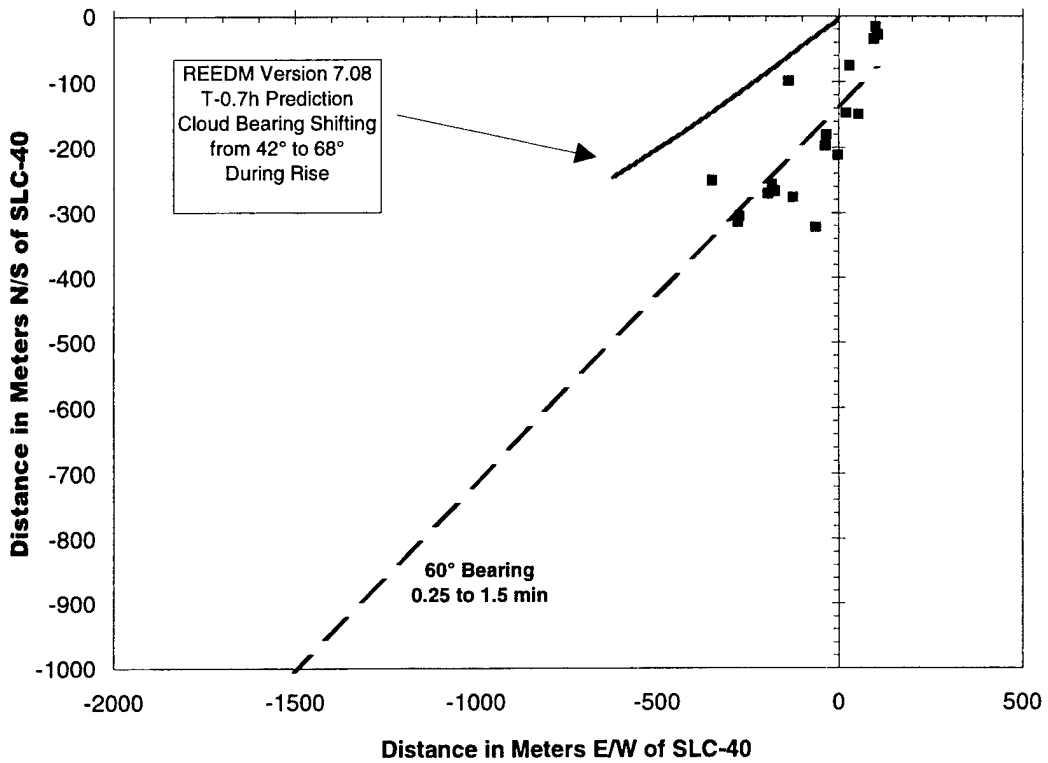
Figure 14. Predicted and measured bearings (PLMTRACK upper and PLMVOL lower).
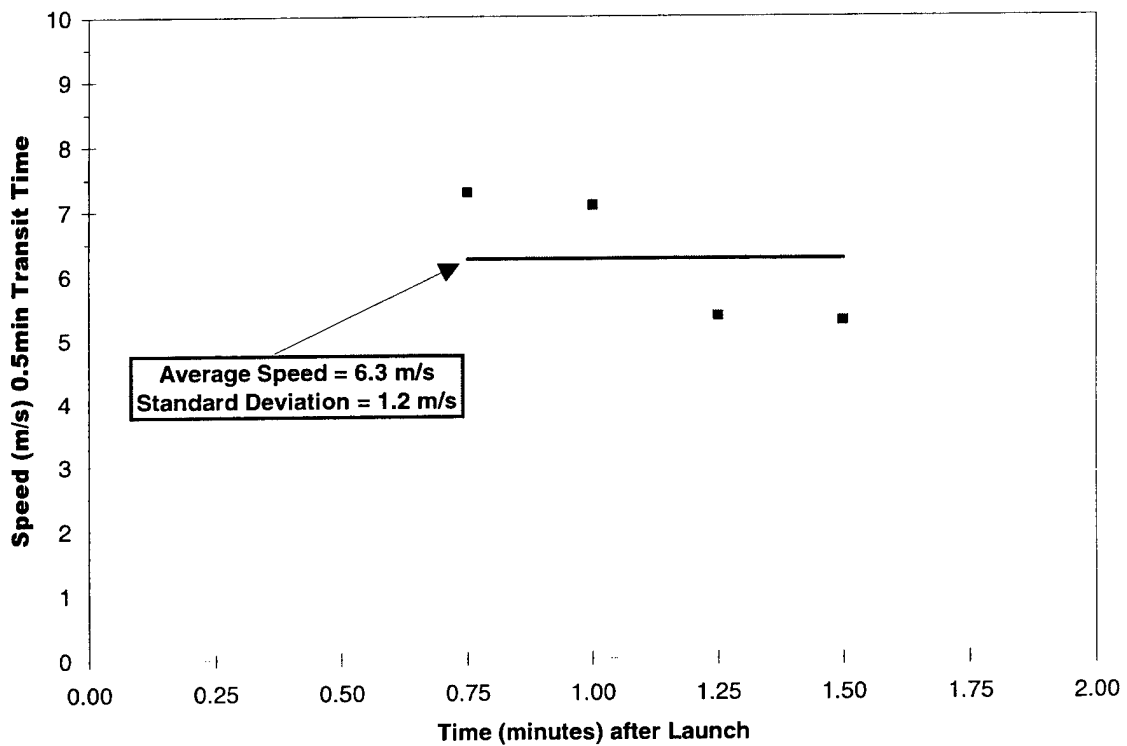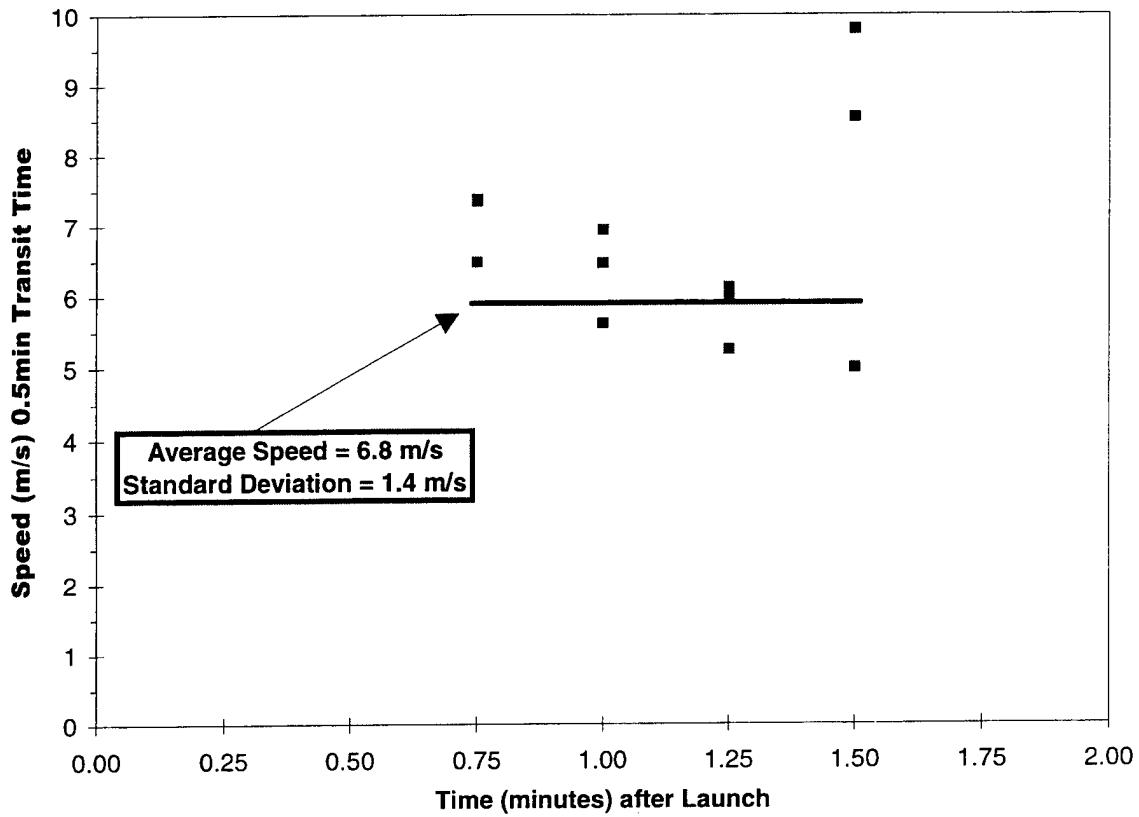
Figure 15. Imagery-derived cloud speed (PLMTRACK upper and PLMVOL lower).

Figure 14 plots the Cartesian coordinates for the ground cloud between 0.5 and 1.5 min after launch. In the upper plot, the **PLMTRACK**-derived middle of the ground cloud is plotted as distance north/south and distance east/west of SLC-40. This plot reveals that the cloud's center is displaced to the east of the pad as a result of the exhaust duct geometry at SLC-40. Between 0.25 and 1.5 min after launch, the cloud had an average bearing of 60° (southwesterly movement). For comparison, the upper plot in Figure 14 includes the REEDM -prediction between 0 and 1.8 min after launch. During this period, the predicted bearing shifted from 42° to 68°. REEDM initializes with the middle of the cloud above the pad.

The lower plot in Figure 14 documents the **PLMVOL** results for the bottom and center of the cloud, which moved along a 59° bearing and a 63° bearing, respectively. There is slightly more scatter in the bottom data than in the center data. This scatter documents the difficulty in defining the bottom of the cloud. PLMVOL reports the average position for all intersected volume elements that are at the lowest altitude. Eddy structure at the edges of the cloud caused fluctuations not only in the number of lowest altitude volume elements (i.e., the shape of the bottom) but also in their placement relative to the center of the cloud (i.e., the position of the lowest eddies along the bottom edge).

PLMVOL analysis uses a detailed outline about the ground cloud and uses imagery from all available sites simultaneously. **PLMTRACK** analysis uses a rectangle to mark only the broadest extend of the cloud and uses the imagery in a pair-wise fashion. Therefore, the **PLMVOL** results should provide better accuracy than the **PLMTRACK** results. This is consistent with larger scatter in **PLMTRACK**'s "middle" data in the upper plot than in **PLMVOL**'s "center" data in the lower plot. However, both methods document a displacement to the east of the pad at early times, which is consistent with the exhaust duct configuration at SLC-40.

Figure 15 documents the 0.5-min differential speed for the ground cloud during the 1.5 min of available imagery. The **PLMTRACK** results are in the upper plot while the **PLMVOL** results are in the lower plot. These results are from calculations using position data separated by 0.5-min intervals. It appears that the cloud's speed may have dropped slightly during the first 1.5 min after launch. The plots include the average and standard deviation for the cloud's speed. The **PLMTRACK** result of 6.8±1.4 m/s agrees with the **PLMVOL** result of 6.3±1.2 m/s. As mentioned previously, the **PLMVOL** analysis should provide a better value. The **PLMVOL** analysis also provides a separate value for the bottom of the cloud (i.e., 8.2±3.3 m/s). The relatively large standard deviation documents the difficulty in defining the bottom of the cloud (i.e., discussed in the preceding paragraphs). The eddy structures near the bottom of the cloud result in scatter in the differential speed for short-duration comparisons. Since the wind speed varies with altitude, and the cloud is rising throughout the imaged period, it would not be reasonable to fit the data for longer periods.

Figure 16 documents **PLMVOL** results as an increase in cloud volume with time. Figure 17 conveys the same **PLMVOL** results as an increase in the cloud's sphere-equivalent radius with altitude. The sphere-equivalent radius is the radius of a sphere that has the same volume as measured by **PLMVOL**. The slope of a fit to sphere-equivalent radius plotted against altitude is, by definition, the entrainment coefficient used by REEDM. Therefore, Figure 17 documents a
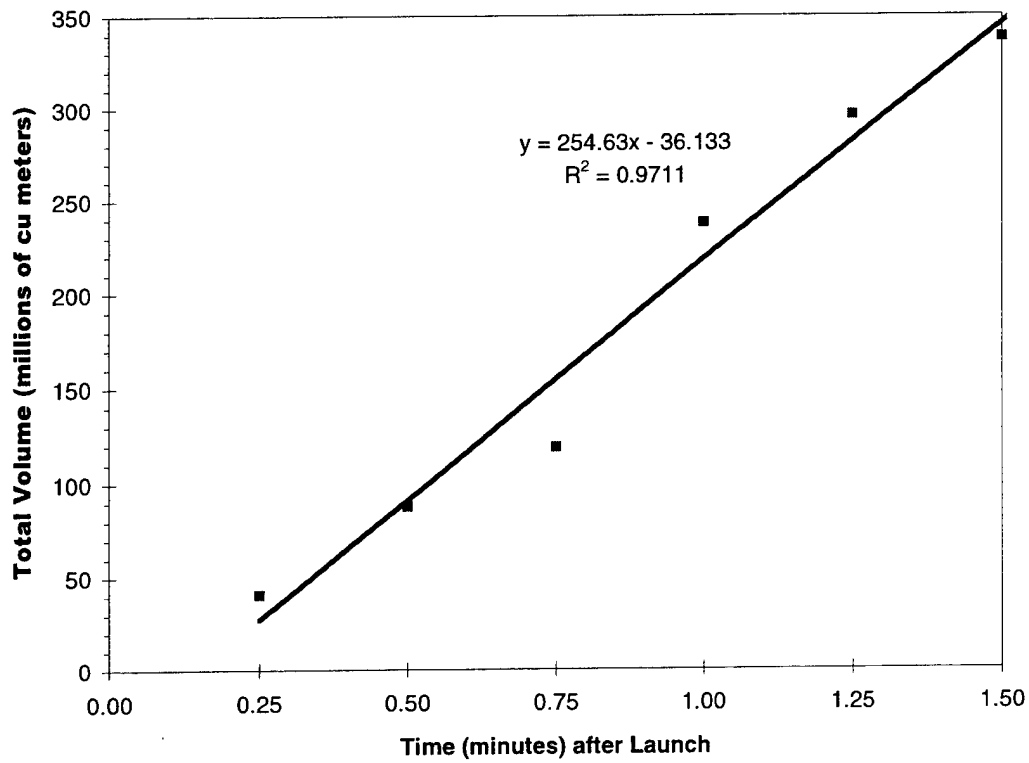
Figure 16. Cloud volume versus time.
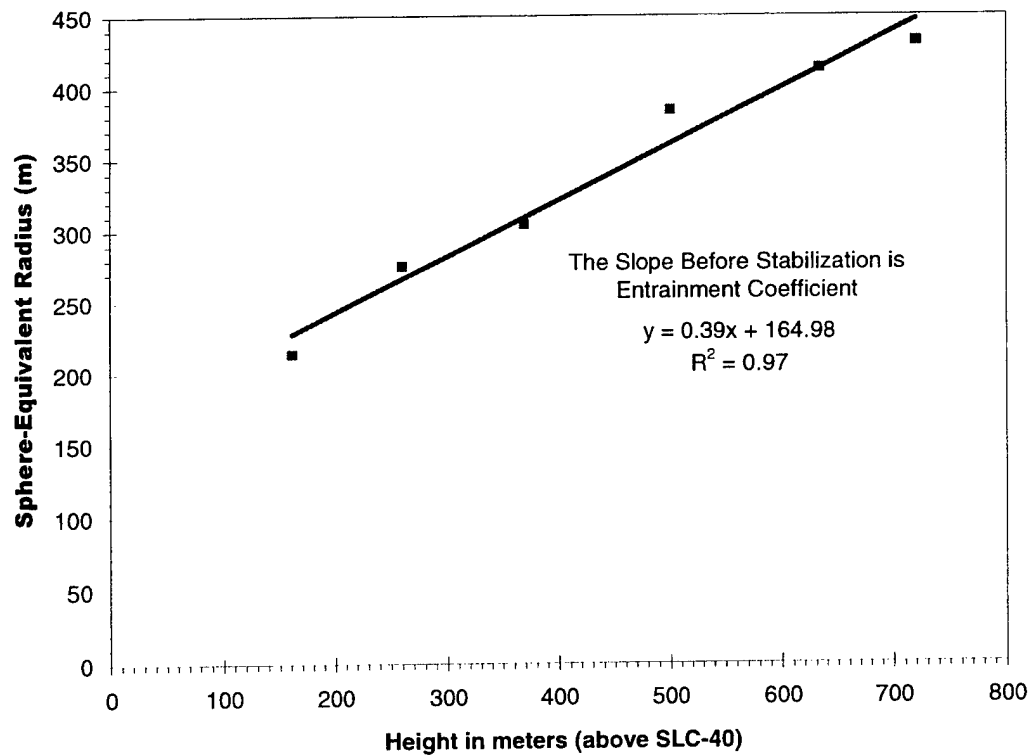
Figure 17. Sphere-equivalent radius versus altitude.

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measured entrainment coefficient of 0.39. This is comparable to the imagery-derived entrainment coefficients for the 34D-9 abort cloud (i.e., 0.35), for two Titan IVA launches (i.e., 0.35 for #K23 and 0.37 for #K19), and for the first Titan IVB launch (i.e., 0.35 for #B24). All of the imagery-derived values are substantially smaller than REEDM's default value of 0.64.

2.5.5   Comparison of REEDM Prediction to Imagery Data—Summary Table

Table 3 summarizes the imagery-derived, the T-0.7 h rawinsonde-measured, and the T-0.7 h REEDM-predicted data for the #B33 ground cloud. Several conclusions can be derived from review of the contents of this table and from previous discussions in this section:

- There is no imagery-derived stabilization height since the ground cloud rose into the low-lying atmospheric clouds before it stabilized.

- The imagery-derived rise curve for the bottom of the cloud documented a stabilization height greater than 514 m AGL, which is at least 7% higher than the T-0.7 h REEDM-predicted stabilization height of 480 m AGL.

- The imagery-derived bearing and speed are is fair agreement with both the T-0.7 h rawinsonde winds and with the T-0.7 h REEDM Version 7.08 predictions.

- The imagery-derived entrainment coefficient (0.39) is 39% smaller than REEDM's default value (0.64).

- The imagery-derived extrapolated initial cloud height is 37 m while REEDM's default value is 0 m.

- The imagery-derived extrapolated initial cloud radius (165 m) is 130% larger than REEDM's default value (72m).

- The imagery documented a linear increase in height with time for the ground cloud while REEDM predicted significant curvature during the same period.

We ran REEDM Version 7.08 in the research mode using the imagery-derived initial radius (165 m), an initial height equal to the initial radius (165 m), and the imagery-derived entrainment coefficient (0.39). The research run documented a linear increase in cloud height with time over the imaged period and a good fit to the imagery-derived data. However, the predicted stabilization heights for the bottom, middle, and top of the cloud jumped from 480, 1459, and 2433 m (i.e., the nominal run using the default settings) to 1032, 1675, and 2276 m for the research run. Therefore, the predicted vertical extent of the cloud decreases by 35% while the predicted stabilization height increases by only 15% by changing these REEDM parameters. These differences would have dramatic affects upon the predicted ground concentrations. Unfortunately, there is no imagery to referee these differences for the #B33 mission. However, there is now a substantial

database of Titan IVA exhaust cloud imagery (i.e., 14 launches) that can be used to tune REEDM parameters to fit observations.

Table 3. Summary of #B33 Ground Cloud Data Derived from Infrared Imagery,
T-0.7 h Rawinsonde Sounding Data, and T-0.7 h REEDM Predictions

Attribute	Feature	Imagery (IR only)	Rawinsonde (T-0.7 h)	REEDM 7.08 (T-0.7 h)
Stabilization Height	Top			2433
Meters above SLC-40	Middle			1459
(SLC-40 = 7 m MSL)	Bottom	>514		480
Stabilization Time	Top			
Minutes after launch	Middle			6.86
	Bottom	>2.25		
Bearing (°)	Top		57	
(rawinsonde)	Middle		67	68
at Specified Levels	Bottom		69	
Bearing (°)	After Stab.			68
(rawinsonde)	To Max.			71
During Time Interval	During Rise	60–63	40–75	42–68
Speed (m/s)	Top		12.3	
(along trajectory)	Middle		6.7	7.1
at Specified Levels	Bottom		7.4	
Speed (m/s)	After Stab.			7.1
(along trajectory)	To Max.			
During Time Interval	During Rise	6.5±1.4	3.1–8.7	6.7
Entrainment Coeff.	During Rise	0.39		0.64
Initial Radius (m)	At height = 0	165		72
Initial Height (m)	At t = 0	37		0
Rise Rate (time)	During rise	Linear		2nd order

2.6 Summary and Conclusions

The Titan IVB #B33 mission was launched successfully from the Eastern Range (SLC-40) at 04:43 EDT (08:43 GMT) on 15 October 1997. Personnel from The Aerospace Corporation imaged the ground cloud for 2.5 min after the launch from three camera sites. When combined with the AZ/EL readings and the IRIG-B time data, the quantitative imagery documented the rise, stabilization, growth, speed, and bearing of the ground cloud. The cloud rose at a linear rate with time until the top of the cloud penetrated the low-lying atmospheric clouds at 1.5 min after the launch. The bottom of the cloud continued to rise at a linear rate through 2.5 min and 514 m AGL. At that time, poor contrast prevented further tracking. This quantitative imagery data for the #B33 ground cloud will be useful for tuning current and future dispersion models.

The definition of the #B33 exhaust cloud's geometric features was complicated by its three-dimensional shape (i.e., not spherical). However, the imagery successfully documented this complex shape as the cloud evolved (i.e., asymmetric ejection from the exhaust duct, rapid rise of the hot ground cloud, and penetration into the low-lying atmospheric clouds).

Analysis of the imagery data presented in this report has focused on determining parameters that are directly comparable to REEDM predictions. The imagery-derived cloud bearing and speed were similar to T-0.7 h rawinsonde winds and to T-0.7 h REEDM version 7.08 predictions. However, the imagery documented several differences between the ground cloud and REEDM predictions:

- The imagery-derived stabilization height for the bottom of the cloud is greater than 514 m AGL, which is at least 7% higher than REEDM predicted (480 m AGL).

- The imagery-derived entrainment coefficient (0.39) is 39% smaller than REEDM's default value (0.64).

- The imagery-derived extrapolated initial cloud height is 37 m while REEDM's default value is 0 m.

- The imagery-derived extrapolated initial cloud radius (165 m) is 130% larger than REEDM's default value (72m).

- The imagery documented a linear increase in height with time for the ground cloud while REEDM predicted significant curvature during the same period.

References

1. Abernathy, R. N., "Titan 34D-9 Abort Cloud Measurements—Quantitative Imagery from Two Camera Sites," The Aerospace Corporation Technical Report TR-98(1410)-1, The Aerospace Corporation, El Segundo, CA (20 February 1998).

2. Abernathy, R. N., R. F. Heidner III, B. P. Kasper, and J. T. Knudtson, "Visible and Infrared Imagery of the Launch of the Titan IV K-23 from Cape Canaveral Air Force Station on 14 May 1995," Aerospace Report No. TOR-96(1410)-1, The Aerospace Corporation, El Segundo, CA (15 September 1996).

3. Bjorklund, J. R., "User's Manual for the REEDM Version 7 (Rocket Exhaust Effluent Diffusion Model) Computer Program," Vol. I, TR-90-157-01, AF Systems Command, Patrick AFB, FL (April 1990).

4. Womack, J. M., "Rocket Exhaust Effluent Diffusion Model Sensitivity Study," TOR-95(5448)-3, The Aerospace Corporation, El Segundo, CA (May 1995).

Appendix A—REEDM Version 7.08 Predictions for the #B-33 Mission

[The material in this section was contributed by R. N. Abernathy of the Environmental Monitoring and Technology Department of The Aerospace Corporation's Space and Environment Technology Center.]

This Appendix includes REEDM version 7.08 runs for impact at both the surface (0 m AGL, 7 m MSL) and stabilization height (predicted by REEDM). We include the plots of the rawinsonde meteorological data, the predicted maximum concentration versus downwind distance, and the predicted concentration isopleths overlayed on a range map. These plots are followed by the detailed REEDM report for that run.

Stabilization Height Predictions

The following figures and table are the REEDM version 7.08 output for the stabilization height run. These predictions were compared with actual B-33 ground cloud observations in Chapter 2 for the quantitative imagery. The first page of the REEDM output is its listing of errors and is not included in this appendix.

Figure 1: Meteorological Output Plot from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.

Figure 2: HCl Stabilization Height Concentration Predictions from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.

A-2
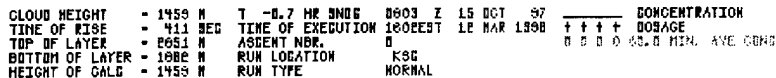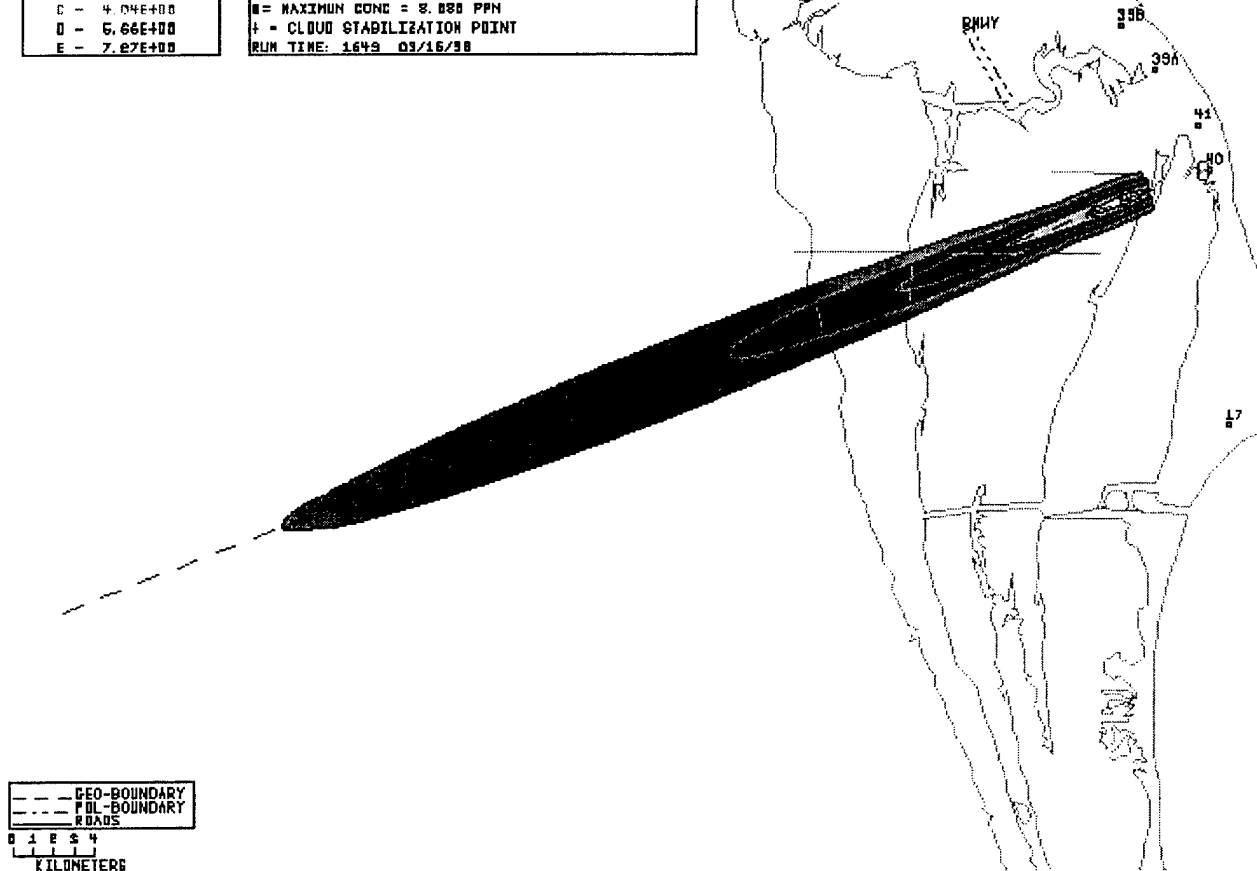
Figure 3: HCl Stabilization Height Concentration Isopleth Predictions from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   2
VERSION 7.08 AT KSC
1649 EST 16 MAR 1998
launch time: 0443 EDT 15 OCT 1997
RAWINSONDE ASCENT NUMBER   0, 0803 Z 15 OCT 97 T -0.7 HR
****

----- PROGRAM OPTIONS -----

MODEL	CONCENTRATION
RUN TYPE	OPERATIONAL
WIND-FIELD TERRAIN EFFECTS MODEL	NONE
LAUNCH VEHICLE	TITAN IVB SRMU
LAUNCH TYPE	NORMAL
LAUNCH COMPLEX NUMBER	40
TURBULENCE PARAMETERS ARE DETERMINED FROM	CLIMATOLOGICAL DATA
SURFACE CHEMISTRY MODEL	absorption coefficient
SPECIES SURFACE FACTOR	HCL 0.000
CLOUD SHAPE	ELLIPTICAL
CALCULATION HEIGHT	STABILIZATION
PROPELLANT TEMPERATURE (DEG. C)	26.29
CONCENTRATION AVERAGING TIME (SEC.)	3600.00
mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)	1.0000
DIFFUSION COEFFICIENTS LATERAL	1.0000
VERTICAL	1.0000
GAMMAE	0.6400
VEHICLE AIR ENTRAINMENT PARAMETER LATERAL	100.00
DOWNWIND EXPANSION DISTANCE (METERS) VERTICAL	100.00

----- DATA FILES -----

INPUT FILES

RAWINSONDE FILE	rm0803.288
DATA BASE FILE	rdmbase.ksc

OUTPUT FILES

PRINT FILE	b3380803.stb
PLOT FILE	b3380803.stp

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   3
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****

----- METEOROLOGICAL RAWINSONDE DATA -----

RAWINSONDE MSS/MSS
TIME- 0803   Z   DATE- 15 OCT   97
ASCENT NUMBER   0

----- T -0.7 HR SOUNDING -----

MET. LEV. NO.	MSL (FT)	ALTITUDE GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	TEMP (DEG C)	AIR PTEMP (DEG C)	DPTEMP (DEG C)	AIR PRESS (MB)	AIR RH (%)	H M	INT-ERP
1	16	0.0	0.0	40	3.1	6.0	23.9	25.0	18.0	1014.1	70.0		
2	60	44.0	13.4	47	4.5	8.7	24.1	25.3	18.0	1012.5	68.7		**
3	104	88.0	26.8	54	5.9	11.5	24.3	25.6	18.0	1011.0	67.9		**
4	148	132.0	40.2	61	7.3	14.2	24.4	25.9	17.9	1009.4	67.1		**
5	192	176.0	53.6	68	8.7	17.0	24.6	26.2	17.9	1007.9	66.0		
6	268	251.7	76.7	68	8.6	16.7	24.4	26.3	17.7	1005.3	66.1		**
7	343	327.3	99.8	68	8.4	16.3	24.3	26.3	17.5	1002.6	66.0		**
8	419	403.0	122.8	68	8.2	16.0	24.1	26.3	17.3	1000.0	66.0		
9	613	596.7	181.9	68	8.1	15.7	23.6	26.3	16.9	993.3	66.4		**
10	806	790.3	240.9	67	7.9	15.3	23.0	26.4	16.6	986.6	67.0		**
11	1000	984.0	299.9	67	7.7	15.0	22.5	26.4	16.2	980.0	68.0		
12	1295	1278.7	389.7	68	7.5	14.7	21.5	26.3	16.1	969.9	71.3		**
13	1589	1573.3	479.6	69	7.4	14.3	20.6	26.2	16.0	959.9	75.2		**
14	1884	1868.0	569.4	70	7.2	14.0	19.6	26.1	15.9	950.0	79.0		
15	2000	1984.0	604.7	70	7.2	14.0	19.2	26.1	15.9	946.2	81.0		
16	2591	2575.0	784.9	72	7.2	14.0	17.3	25.9	15.4	926.6	89.0		
17	3000	2984.0	909.5	74	6.8	13.3	16.1	25.8	14.8	913.3	92.0		
18	3115	3099.0	944.6	74	6.7	13.0	15.7	25.8	14.6	909.5	93.0		
19	3403	3387.0	1032.4	75	6.7	13.0	15.1	26.0	13.8	900.0	92.0		
20	4000	3984.0	1214.3	73	6.5	12.7	14.0	26.5	12.3	881.1	89.0		
21	4849	4833.0	1473.1	67	6.7	13.0	11.9	26.8	10.6	854.5	92.0		
22	5000	4984.0	1519.1	66	6.7	13.1	11.7	27.0	10.0	849.9	90.0		
23	5500	5484.0	1671.5	62	7.2	13.9	10.6	27.4	8.7	834.5	87.9		**
24	6000	5984.0	1823.9	58	7.6	14.8	9.6	27.7	7.4	819.5	86.0		
25	6193	6177.0	1882.7	54	8.7	17.0	9.1	27.8	7.4	813.7	89.0	*	
26	6385	6369.0	1941.3	53	11.3	22.0	9.8	28.9	4.3	808.0	68.0		
27	6647	6631.0	2021.1	52	11.8	23.0	9.5	29.5	4.8	800.0	73.0		
28	7000	6984.0	2128.7	52	12.1	23.6	9.1	30.3	6.4	790.0	84.0		
29	7129	7113.0	2168.0	52	12.3	24.0	8.9	30.6	7.0	786.3	88.0		
30	7307	7291.0	2222.3	52	12.3	24.0	8.8	31.1	7.1	781.2	89.0		
31	7485	7469.0	2276.6	53	12.3	24.0	9.3	31.6	0.6	776.1	54.0		
32	8000	7984.0	2433.5	57	12.3	24.0	8.5	32.1	-4.8	761.6	38.0		
33	8401	8385.0	2555.7	59	12.3	24.0	7.9	32.7	-7.5	750.0	33.0		
34	9371	9355.0	2851.4	64	12.3	24.0	7.4	35.1	-12.0	724.0	24.0		

* - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER
** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   4
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****

----- METEOROLOGICAL RAWINSONDE DATA -----

SURFACE AIR DENSITY (GM/M**3)   1180.14
DEFAULT CALCULATED MIXING LAYER HEIGHT (M)   1882.75
CLOUD COVER IN TENTHS OF CELESTIAL DOME   0.0
CLOUD CEILING (M)   9999.0
----- PLUME RISE DATA -----

EXHAUST RATE OF MATERIAL INTO GRN CLD-   (GRAMS/SEC)   5.40592E+06
TOTAL GROUND CLD MATERIAL-   (GRAMS)   5.37669E+07
HEAT OUTPUT PER GRAM-   (CALORIES)   1555.6
VEHICLE RISE HEIGHT DEFINING GROUND CLD- (M)   199.9
VEHICLE RISE TIME PARAMETERS-   (TK=(A*Z**B)+C) A=   0.9519
                                                         B=   0.4429
                                                         C=   0.0000
EXHAUST RATE OF MATERIAL INTO CONTRAIL- (GRAMS/SEC)   5.40592E+06
CONTRAIL HEAT OUTPUT PER GRAM-   (CALORIES)   1555.6

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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   5
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                    ----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	13.4	1.3	2.3	222.3	0.0	0.0
2	26.8	2.1	6.8	225.5	0.0	0.0
3	40.2	2.8	11.1	228.9	0.0	0.0
4	53.6	3.5	16.2	232.9	0.0	0.0
5	76.7	4.8	24.7	237.9	0.0	0.0
6	99.8	6.2	36.1	241.1	0.0	0.0
7	122.8	7.7	48.4	242.9	0.0	0.0
8	181.9	12.3	73.5	244.6	0.0	0.0
9	240.9	17.9	114.3	245.7	0.0	0.0
10	299.9	24.3	161.5	246.2	0.0	0.0
11	389.7	35.8	230.6	246.5	0.0	0.0
12	479.6	49.2	324.4	246.9	0.0	0.0
13	569.4	64.5	430.4	247.4	2957.4	249.2
14	604.7	71.1	509.4	247.8	2959.5	249.6
15	784.9	108.7	668.1	248.4	2847.5	250.4
16	909.5	139.1	911.2	249.4	2821.7	251.8
17	944.6	148.3	1047.8	249.9	2825.2	252.5
18	1032.4	173.0	1161.0	250.3	2753.3	252.7
19	1214.3	232.7	1441.4	251.2	2621.3	252.4
20	1473.1	411.3 *	2817.3	250.9	2817.3	250.9
21	1519.1	411.3 *	2817.3	250.9	2817.3	250.9
22	1671.5	411.3 *	2817.3	250.9	2817.3	250.9
23	1823.9	411.3 *	2817.3	250.9	2817.3	250.9
24	1882.7	411.3 *	2817.3	250.9	2817.3	250.9
25	1941.3	411.3 *	2817.3	250.9	2817.3	250.9
26	2021.1	411.3 *	2817.3	250.9	2817.3	250.9
27	2128.7	411.3 *	2817.3	250.9	2817.3	250.9
28	2168.0	411.3 *	2817.3	250.9	2817.3	250.9
29	2222.3	411.3 *	2817.3	250.9	2817.3	250.9
30	2276.6	411.3 *	2817.3	250.9	2817.3	250.9
31	2433.5	411.3 *	2817.3	250.9	2817.3	250.9
32	2555.7	411.3 *	2817.3	250.9	2817.3	250.9
33	2851.4	411.3 *	2817.3	250.9	2817.3	250.9

          * - INDICATES CLOUD STABILIZATION TIME WAS USED

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----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)	LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION ALONGWIND (METERS)	MATERIAL DIST. CROSSWIND (METERS)
1	13.4	0.00000E+00	16.2	0.0	0.0	0.0
2	26.8	0.00000E+00	18.7	0.0	0.0	0.0
3	40.2	0.00000E+00	19.0	0.0	0.0	0.0
4	53.6	0.00000E+00	18.5	0.0	0.0	0.0
5	76.7	0.00000E+00	17.1	0.0	0.0	0.0
6	99.8	0.00000E+00	15.7	0.0	0.0	0.0
7	122.8	0.00000E+00	14.3	0.0	0.0	0.0
8	181.9	0.00000E+00	11.6	0.0	0.0	0.0
9	240.9	0.00000E+00	9.8	0.0	0.0	0.0
10	299.9	0.00000E+00	8.6	0.0	0.0	0.0
11	389.7	0.00000E+00	7.2	0.0	0.0	0.0
12	479.6	0.00000E+00	6.2	0.0	0.0	0.0
13	569.4	2.55996E+04	5.5	57.8	27.0	27.0
14	604.7	5.76814E+04	5.3	357.6	166.6	166.6
15	784.9	7.57617E+05	4.4	576.6	268.7	268.7
16	909.5	9.14410E+05	3.9	758.9	353.6	353.6
17	944.6	3.05188E+05	3.7	825.8	384.8	384.8
18	1032.4	8.43722E+05	3.4	868.0	404.5	404.5
19	1214.3	2.03664E+06	2.7	937.9	437.1	437.1
20	1473.1 *	3.38134E+06	0.0	997.6	464.9	464.9
21	1519.1 *	9.70935E+05	0.0	1004.6	468.1	468.1
22	1671.5 *	3.12873E+06	0.0	994.6	463.5	463.5
23	1823.9 *	2.92277E+06	0.0	956.1	445.5	445.5
24	1882.7 *	1.05246E+06	0.0	911.4	424.7	424.7
25	1941.3 *	9.96597E+05	0.0	879.2	409.7	409.7
26	2021.1 *	1.26867E+06	0.0	833.5	388.4	388.4
27	2128.7 *	1.51950E+06	0.0	755.7	352.1	352.1
28	2168.0 *	4.94761E+05	0.0	678.1	316.0	316.0
29	2222.3 *	6.24670E+05	0.0	618.5	288.2	288.2
30	2276.6 *	5.53264E+05	0.0	535.2	249.4	249.4
31	2433.5 *	1.18010E+06	0.0	282.6	131.7	131.7
32	2555.7 *	7.55028E+05	0.0	199.9	93.2	93.2
33	2851.4 *	1.74695E+06	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)	1459.34
STABILIZATION HEIGHT	(METERS)	1459.34
STABILIZATION TIME	(SECS)	411.32
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP = 1882.75
		BASE= 0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP = 2851.40
		BASE= 1882.75
SIGMAR(AZ) AT THE SURFACE	(DEGREES)	7.4561
SIGMER(EL) AT THE SURFACE	(DEGREES)	4.9445

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	4.03	1.41	43.50	7.00	5.9462	4.3792
2	5.21	1.41	50.50	7.00	4.1491	3.6863
3	6.62	1.41	57.50	7.00	3.7116	3.4879
4	8.04	1.41	64.50	7.00	3.4616	3.3687
5	8.66	-0.17	68.00	0.00	3.2828	3.2619
6	8.49	-0.17	68.00	0.00	3.1621	3.1621
7	8.32	-0.17	68.00	0.00	3.0890	3.0890
8	8.15	0.17	67.83	-0.33	3.0224	3.0224
9	7.97	-0.17	67.50	-0.33	2.9523	2.9523
10	7.80	-0.17	67.17	-0.33	2.8729	2.8729
11	7.63	0.17	67.50	1.00	2.7753	2.7753
12	7.46	0.17	68.50	1.00	2.6685	2.6685
13	7.29	0.17	69.50	1.00	2.5779	2.5779
14	7.20	0.00	70.00	0.00	2.4766	2.4766
15	7.20	0.00	71.00	2.00	2.3219	2.3219
16	7.02	0.36	73.00	2.00	2.1839	2.1839
17	6.76	0.15	74.00	0.00	2.0999	2.0999
18	6.69	0.00	74.50	1.00	1.9832	1.9832
19	6.61	-0.15	74.00	-2.00	1.7720	1.7720
20	6.61	0.15	70.00	-6.00	1.5503	1.5503
21	6.71	0.05	66.50	-1.00	1.4007	1.4007
22	6.96	0.44	64.00	-4.00	1.2512	1.2512
23	7.40	0.44	60.00	-4.00	1.0978	1.0978
24	8.18	1.13	56.00	-4.00	1.0175	1.0175
25	10.03	2.57	53.50	-1.00	1.0000	1.0000
26	11.57	0.51	52.50	-1.00	1.0000	1.0000
27	11.99	0.31	52.00	0.00	1.0000	1.0000
28	12.24	0.21	52.00	0.00	1.0000	1.0000
29	12.35	0.00	52.00	0.00	1.0000	1.0000
30	12.35	0.00	52.50	1.00	1.0000	1.0000

----- CALCULATED METEOROLOGICAL LAYER PARAMETERS -----

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
31	12.35	0.00	55.00	4.00	1.0000	1.0000
32	12.35	0.00	58.00	2.00	1.0000	1.0000
33	12.35	0.00	61.50	5.00	1.0000	1.0000

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS   240.9 TO   2851.4 METERS.

TRANSITION LAYER NUMBER-   1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	1882.75	300.96	8.75		54.00		1.0000	1.0000
LAYER-			7.05	0.47	68.50	5.58	1.9013	1.9013
BOTTOM-	0.00	298.17	3.09		40.00		7.4561	4.9445

TRANSITION LAYER NUMBER-   2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	2851.40	308.30	12.35		64.00		1.0000	1.0000
LAYER-			12.07	0.85	56.37	4.15	1.0000	1.0000
BOTTOM-	1882.75	300.96	8.75		54.00		1.0000	1.0000

               ----- MAXIMUM CENTERLINE CALCULATIONS -----

               ** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

            CONCENTRATION OF HCL AT A HEIGHT OF 1459.3 METERS
              DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
         CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
3000.0000	250.7590	7.1908	4.9077	9.6678
4000.0000	250.5260	8.0803	4.9245	12.0329
5000.0000	249.9522	7.7824	6.1509	14.4014
6000.0000	249.5755	7.3874	7.8932	16.7701
7000.9414	249.4404	6.9804	9.8732	19.1408
8000.8066	249.3144	6.5787	12.2266	21.5100
9000.7842	249.2571	6.1982	14.5778	23.8800
10000.8506	249.2479	5.8432	16.9267	26.2510
11000.6631	249.1299	5.5122	19.2735	28.6229
12000.8408	249.1788	5.2008	21.6183	30.9957
13000.7070	249.0983	4.9072	23.9613	33.3693
14000.5957	249.0294	4.6273	26.3026	35.7438
15000.5020	248.9696	4.3604	28.6422	38.1192
16000.4229	248.9173	4.1064	30.9804	40.4954
17000.3555	248.8711	3.8656	33.3172	42.8725
18000.6563	248.9897	3.6381	35.6526	45.2503
19000.5957	248.9543	3.4245	37.9870	47.6290
20000.5410	248.9224	3.2237	40.3202	50.0085
21000.4941	248.8935	3.0353	42.6524	52.3888
22000.4512	248.8673	2.8588	44.9837	54.7698
23000.4121	248.8434	2.6937	47.3142	57.1516
24000.3770	248.8214	2.5395	49.6439	59.5342
25000.3438	248.8012	2.3954	51.9728	61.9174
26000.3145	248.7826	2.2611	54.3011	64.3014
27000.2871	248.7653	2.1359	56.6288	66.6861
28000.2637	248.7493	2.0192	58.9559	69.0714
29000.2402	248.7344	1.9105	61.2826	71.4574
30000.2207	248.7204	1.8094	63.6087	73.8441
31000.2012	248.7074	1.7154	65.9344	76.2314
32000.1836	248.6952	1.6279	68.2596	78.6193
33000.1680	248.6837	1.5466	70.5845	81.0078
34000.1523	248.6729	1.4710	72.9090	83.3969
35000.1406	248.6628	1.4007	75.2332	85.7866
36000.1289	248.6531	1.3353	77.5571	88.1768
37000.1172	248.6440	1.2745	79.8807	90.5676

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****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 1459.3 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
38000.1055	248.6354	1.2180	82.2041	92.9589
39000.0938	248.6272	1.1653	84.5272	95.3507
40000.0859	248.6195	1.1163	86.8500	97.7430
41000.0781	248.6121	1.0705	89.1727	100.1358
42000.0703	248.6051	1.0278	91.4951	102.5290
43000.0625	248.5983	0.9880	93.8173	104.9227
44000.0547	248.5919	0.9507	96.1394	107.3169
45000.0508	248.5858	0.9157	98.4613	109.7115
46000.0430	248.5800	0.8830	100.7830	112.1065
47000.4414	248.7491	0.8522	103.1046	114.5019
48000.4336	248.7439	0.8234	105.4260	116.8978
49000.4219	248.7390	0.7961	107.7473	119.2940
50000.4141	248.7342	0.7705	110.0685	121.6905
51000.4063	248.7296	0.7462	112.3895	124.0875
52000.3984	248.7252	0.7233	114.7105	126.4848
53000.3906	248.7210	0.7015	117.0313	128.8824
54000.3828	248.7169	0.6808	119.3521	131.2804
55000.3789	248.7130	0.6612	121.6727	133.6787
56000.3711	248.7092	0.6425	123.9932	136.0773
57000.3633	248.7055	0.6246	126.3137	138.4762
58000.3594	248.7020	0.6076	128.6341	140.8754
59000.3516	248.6986	0.5913	130.9543	143.2749
60000.3477	248.6953	0.5757	133.2746	145.6746

	RANGE	BEARING
8.080 IS THE MAXIMUM PEAK CONCENTRATION	4000.0	250.5

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ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   11
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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 1459.3 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

| | | 60.0 MIN.
MEAN | CLOUD | CLOUD |
RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	CONCEN- TRATION (PPM)	ARRIVAL TIME (MIN)	DEPARTURE TIME (MIN)
3000.0000	250.7590	0.3303	4.9077	9.6678
4000.0000	250.5260	0.3721	4.9245	12.0329
5000.0000	249.9522	0.3581	6.1509	14.4014
6000.0000	249.5755	0.3395	7.8932	16.7701
7000.9414	249.4404	0.3199	9.8732	19.1408
8000.8066	249.3144	0.3006	12.2266	21.5100
9000.7842	249.2571	0.2823	14.5778	23.8800
10000.8506	249.2479	0.2654	16.9267	26.2510
11000.6631	249.1299	0.2498	19.2735	28.6229
12000.8408	249.1788	0.2353	21.6183	30.9957
13000.7070	249.0983	0.2219	23.9613	33.3693
14000.5957	249.0294	0.2094	26.3026	35.7438
15000.5020	248.9696	0.1976	28.6422	38.1192
16000.4229	248.9173	0.1866	30.9804	40.4954
17000.3555	248.8711	0.1762	33.3172	42.8725
18000.6563	248.9897	0.1665	35.6526	45.2503
19000.5957	248.9543	0.1575	37.9870	47.6290
20000.5410	248.9224	0.1490	40.3202	50.0085
21000.4941	248.8935	0.1411	42.6524	52.3888
22000.4512	248.8673	0.1337	44.9837	54.7698
23000.4121	248.8434	0.1268	47.3142	57.1516
24000.3770	248.8214	0.1204	49.6439	59.5342
25000.3438	248.8012	0.1144	51.9728	61.9174
26000.3145	248.7826	0.1087	54.3011	64.3014
27000.2871	248.7653	0.1035	56.6288	66.6861
28000.2637	248.7493	0.0986	58.9559	69.0714
29000.2402	248.7344	0.0941	61.2826	71.4574
30000.2207	248.7204	0.0899	63.6087	73.8441
31000.2012	248.7074	0.0859	65.9344	76.2314
32000.1836	248.6952	0.0823	68.2596	78.6193
33000.1680	248.6837	0.0789	70.5845	81.0078
34000.1523	248.6729	0.0757	72.9090	83.3969
35000.1406	248.6628	0.0728	75.2332	85.7866
36000.1289	248.6531	0.0701	77.5571	88.1768

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----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) =   0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 1459.3 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	60.0 MIN. MEAN CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
37000.1172	248.6440	0.0675	79.8807	90.5676
38000.1055	248.6354	0.0652	82.2041	92.9589
39000.0938	248.6272	0.0630	84.5272	95.3507
40000.0859	248.6195	0.0609	86.8500	97.7430
41000.0781	248.6121	0.0590	89.1727	100.1358
42000.0703	248.6051	0.0573	91.4951	102.5290
43000.0625	248.5983	0.0556	93.8173	104.9227
44000.0547	248.5919	0.0541	96.1394	107.3169
45000.0508	248.5858	0.0526	98.4613	109.7115
46000.0430	248.5800	0.0513	100.7830	112.1065
47000.4414	248.7491	0.0500	103.1046	114.5019
48000.4336	248.7439	0.0489	105.4260	116.8978
49000.4219	248.7390	0.0477	107.7473	119.2940
50000.4141	248.7342	0.0467	110.0685	121.6905
51000.4063	248.7296	0.0457	112.3895	124.0875
52000.3984	248.7252	0.0448	114.7105	126.4848
53000.3906	248.7210	0.0439	117.0313	128.8824
54000.3828	248.7169	0.0431	119.3521	131.2804
55000.3789	248.7130	0.0423	121.6727	133.6787
56000.3711	248.7092	0.0415	123.9932	136.0773
57000.3633	248.7055	0.0408	126.3137	138.4762
58000.3594	248.7020	0.0401	128.6341	140.8754
59000.3516	248.6986	0.0394	130.9543	143.2749
60000.3477	248.6953	0.0388	133.2746	145.6746

	RANGE	BEARING
0.372 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION	4000.0	250.5

*** REEDM HAS TERMINATED

Surface Impact Predictions

This section includes the REEDM version 7.08 output for the surface impact run.
For the surface impact run, we included the plots of the rawinsonde
meteorological data, the predicted maximum concentration versus downwind
distance, and the predicted concentration isopleths overlayed on a range map.
The rawinsonde meteorological data is identical to the data plotted in Figure 1
for the stabilization height run. Lastly this section includes the detailed
REEDM report for this run. The first page of the REEDM output is its listing of
errors and is not included in this appendix.

Figure 4: Meteorological Output Plot from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.

Figure 5: HCl Surface Height Concentration Predictions from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.
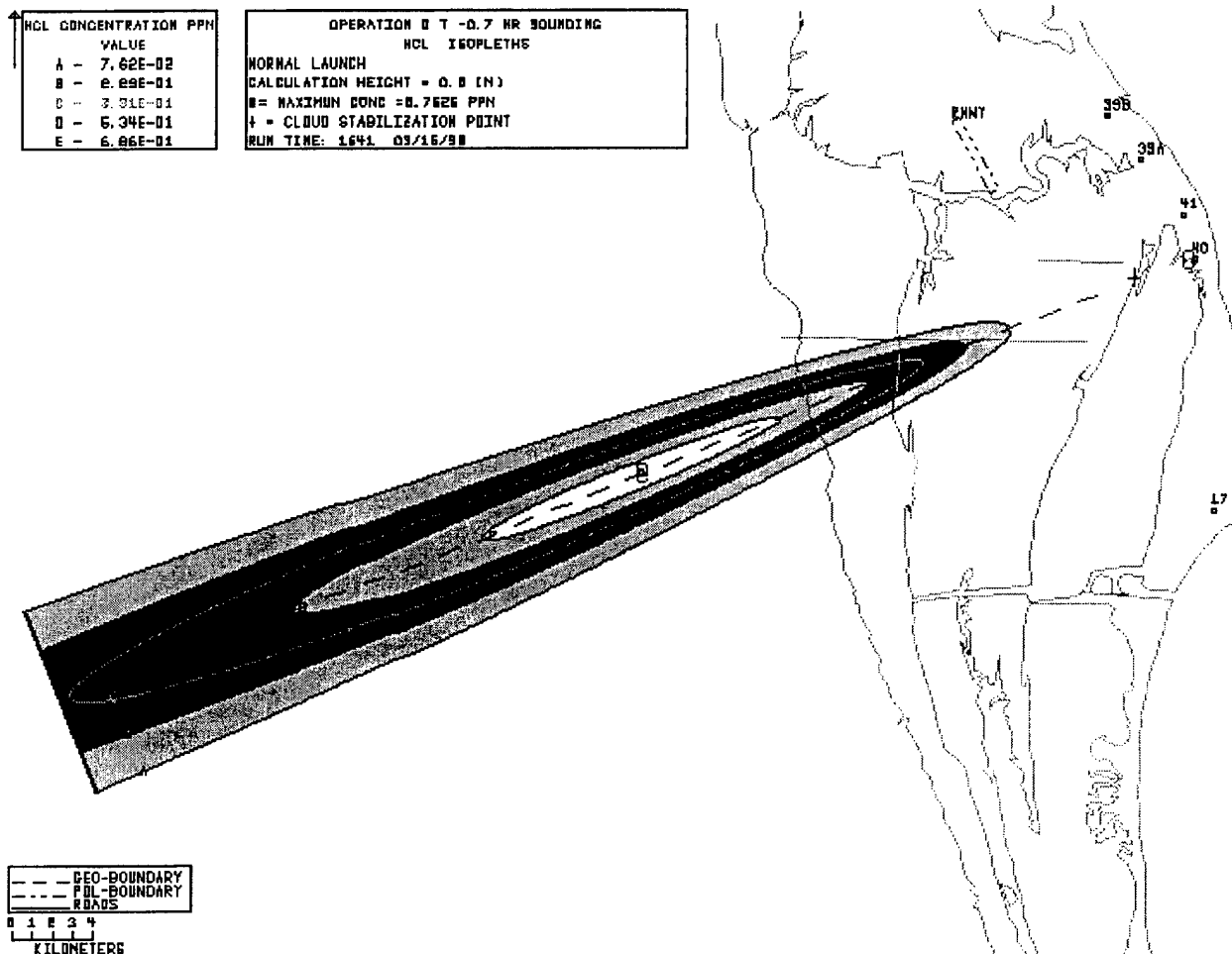
Figure 6: HCl Surface Height Concentration Isopleth Predictions from REEDM Version 7.08 for B-33 Mission Using T-0.8h Rawinsonde Data.

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----- PROGRAM OPTIONS -----

MODEL   CONCENTRATION
RUN TYPE   OPERATIONAL
WIND-FIELD TERRAIN EFFECTS MODEL   NONE
LAUNCH VEHICLE   TITAN IVB SRMU
LAUNCH TYPE   NORMAL
LAUNCH COMPLEX NUMBER   40
TURBULENCE PARAMETERS ARE DETERMINED FROM   CLIMATOLOGICAL DATA
SURFACE CHEMISTRY MODEL   absorption coefficient
SPECIES   SURFACE FACTOR   HCL   0.000
CLOUD SHAPE   ELLIPTICAL
CALCULATION HEIGHT   SURFACE
PROPELLANT TEMPERATURE (DEG. C)   26.29
CONCENTRATION AVERAGING TIME (SEC.)   3600.00
mixing layer reflection coefficient (RNG- 0 TO 1,no reflection=0)   1.0000
DIFFUSION COEFFICIENTS   LATERAL   1.0000
                                               VERTICAL   1.0000
                                               GAMMAE   0.6400
VEHICLE AIR ENTRAINMENT PARAMETER   LATERAL   100.00
DOWNWIND EXPANSION DISTANCE (METERS)   VERTICAL   100.00

----- DATA FILES -----

INPUT FILES

RAWINSONDE FILE   rm0803.288
DATA BASE FILE   rdmbase.ksc

OUTPUT FILES

PRINT FILE   b3380803.sur
PLOT FILE   b3380803.sup

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   3
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****

----- METEOROLOGICAL RAWINSONDE DATA -----

RAWINSONDE MSS/MSS
TIME- 0803   Z   DATE- 15 OCT   97
ASCENT NUMBER   0

----- T -0.7 HR SOUNDING -----

MET. LEV. NO.	ALTITUDE MSL (FT)	GND (FT)	GND (M)	WIND DIR (DEG)	WIND SPEED (M/S)	(KTS)	AIR TEMP	PTEMP (DEG C)	DPTEMP	AIR PRESS (MB)	AIR RH (%)	H M	INT-ERP
1	16	0.0	0.0	40	3.1	6.0	23.9	25.0	18.0	1014.1	70.0		
2	60	44.0	13.4	47	4.5	8.7	24.1	25.3	18.0	1012.5	68.7		**
3	104	88.0	26.8	54	5.9	11.5	24.3	25.6	18.0	1011.0	67.9		**
4	148	132.0	40.2	61	7.3	14.2	24.4	25.9	17.9	1009.4	67.1		**
5	192	176.0	53.6	68	8.7	17.0	24.6	26.2	17.9	1007.9	66.0		
6	268	251.7	76.7	68	8.6	16.7	24.4	26.3	17.7	1005.3	66.1		**
7	343	327.3	99.8	68	8.4	16.3	24.3	26.3	17.5	1002.6	66.0		**
8	419	403.0	122.8	68	8.2	16.0	24.1	26.3	17.3	1000.0	66.0		
9	613	596.7	181.9	68	8.1	15.7	23.6	26.3	16.9	993.3	66.4		**
10	806	790.3	240.9	67	7.9	15.3	23.0	26.4	16.6	986.6	67.0		**
11	1000	984.0	299.9	67	7.7	15.0	22.5	26.4	16.2	980.0	68.0		
12	1295	1278.7	389.7	68	7.5	14.7	21.5	26.3	16.1	969.9	71.3		**
13	1589	1573.3	479.6	69	7.4	14.3	20.6	26.2	16.0	959.9	75.2		**
14	1884	1868.0	569.4	70	7.2	14.0	19.6	26.1	15.9	950.0	79.0		
15	2000	1984.0	604.7	70	7.2	14.0	19.2	26.1	15.9	946.2	81.0		
16	2591	2575.0	784.9	72	7.2	14.0	17.3	25.9	15.4	926.6	89.0		
17	3000	2984.0	909.5	74	6.8	13.3	16.1	25.8	14.8	913.3	92.0		
18	3115	3099.0	944.6	74	6.7	13.0	15.7	25.8	14.6	909.5	93.0		
19	3403	3387.0	1032.4	75	6.7	13.0	15.1	26.0	13.8	900.0	92.0		
20	4000	3984.0	1214.3	73	6.5	12.7	14.0	26.5	12.3	881.1	89.0		
21	4849	4833.0	1473.1	67	6.7	13.0	11.9	26.8	10.6	854.5	92.0		
22	5000	4984.0	1519.1	66	6.7	13.1	11.7	27.0	10.0	849.9	90.0		
23	5500	5484.0	1671.5	62	7.2	13.9	10.6	27.4	8.7	834.5	87.9		**
24	6000	5984.0	1823.9	58	7.6	14.8	9.6	27.7	7.4	819.5	86.0		
25	6193	6177.0	1882.7	54	8.7	17.0	9.1	27.8	7.4	813.7	89.0	*	
26	6385	6369.0	1941.3	53	11.3	22.0	9.8	28.9	4.3	808.0	68.0		
27	6647	6631.0	2021.1	52	11.8	23.0	9.5	29.5	4.8	800.0	73.0		
28	7000	6984.0	2128.7	52	12.1	23.6	9.1	30.3	6.4	790.0	84.0		
29	7129	7113.0	2168.0	52	12.3	24.0	8.9	30.6	7.0	786.3	88.0		
30	7307	7291.0	2222.3	52	12.3	24.0	8.8	31.1	7.1	781.2	89.0		
31	7485	7469.0	2276.6	53	12.3	24.0	9.3	31.6	0.6	776.1	54.0		
32	8000	7984.0	2433.5	57	12.3	24.0	8.5	32.1	-4.8	761.6	38.0		
33	8401	8385.0	2555.7	59	12.3	24.0	7.9	32.7	-7.5	750.0	33.0		
34	9371	9355.0	2851.4	64	12.3	24.0	7.4	35.1	-12.0	724.0	24.0		

 * - INDICATES THE CALCULATED TOP OF THE SURFACE MIXING LAYER
 ** - INDICATES THAT DATA IS LINEARLY INTERPOLATED FROM INPUT METEOROLOGY

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----- METEOROLOGICAL RAWINSONDE DATA -----

SURFACE AIR DENSITY (GM/M**3)   1180.14
DEFAULT CALCULATED MIXING LAYER HEIGHT (M)   1882.75
CLOUD COVER IN TENTHS OF CELESTIAL DOME   0.0
CLOUD CEILING (M)   9999.0
----- PLUME RISE DATA -----

EXHAUST RATE OF MATERIAL INTO GRN CLD-   (GRAMS/SEC)   5.40592E+06
TOTAL GROUND CLD MATERIAL-   (GRAMS)   5.37669E+07
HEAT OUTPUT PER GRAM-   (CALORIES)   1555.6
VEHICLE RISE HEIGHT DEFINING GROUND CLD- (M)   199.9
VEHICLE RISE TIME PARAMETERS-   (TK=(A*Z**B)+C) A=   0.9519
                                                         B=   0.4429
                                                         C=   0.0000

EXHAUST RATE OF MATERIAL INTO CONTRAIL- (GRAMS/SEC)   5.40592E+06
CONTRAIL HEAT OUTPUT PER GRAM-   (CALORIES)   1555.6

ROCKET EXHAUST EFFLUENT DIFFUSION MODEL REEDM   PAGE   5
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****

----- EXHAUST CLOUD -----

MET. LAYER NO.	TOP OF LAYER (METERS)	CLOUD RISE TIME (SECONDS)	CLOUD RISE RANGE (METERS)	CLOUD RISE BEARING (DEGREES)	STABILIZED CLOUD RANGE (METERS)	STABILIZED CLOUD BEARING (DEGREES)
1	13.4	1.3	2.3	222.3	0.0	0.0
2	26.8	2.1	6.8	225.5	0.0	0.0
3	40.2	2.8	11.1	228.9	0.0	0.0
4	53.6	3.5	16.2	232.9	0.0	0.0
5	76.7	4.8	24.7	237.9	0.0	0.0
6	99.8	6.2	36.1	241.1	0.0	0.0
7	122.8	7.7	48.4	242.9	0.0	0.0
8	181.9	12.3	73.5	244.6	0.0	0.0
9	240.9	17.9	114.3	245.7	0.0	0.0
10	299.9	24.3	161.5	246.2	0.0	0.0
11	389.7	35.8	230.6	246.5	0.0	0.0
12	479.6	49.2	324.4	246.9	0.0	0.0
13	569.4	64.5	430.4	247.4	2957.4	249.2
14	604.7	71.1	509.4	247.8	2959.5	249.6
15	784.9	108.7	668.1	248.4	2847.5	250.4
16	909.5	139.1	911.2	249.4	2821.7	251.8
17	944.6	148.3	1047.8	249.9	2825.2	252.5
18	1032.4	173.0	1161.0	250.3	2753.3	252.7
19	1214.3	232.7	1441.4	251.2	2621.3	252.4
20	1473.1	411.3 *	2817.3	250.9	2817.3	250.9
21	1519.1	411.3 *	2817.3	250.9	2817.3	250.9
22	1671.5	411.3 *	2817.3	250.9	2817.3	250.9
23	1823.9	411.3 *	2817.3	250.9	2817.3	250.9
24	1882.7	411.3 *	2817.3	250.9	2817.3	250.9
25	1941.3	411.3 *	2817.3	250.9	2817.3	250.9
26	2021.1	411.3 *	2817.3	250.9	2817.3	250.9
27	2128.7	411.3 *	2817.3	250.9	2817.3	250.9
28	2168.0	411.3 *	2817.3	250.9	2817.3	250.9
29	2222.3	411.3 *	2817.3	250.9	2817.3	250.9
30	2276.6	411.3 *	2817.3	250.9	2817.3	250.9
31	2433.5	411.3 *	2817.3	250.9	2817.3	250.9
32	2555.7	411.3 *	2817.3	250.9	2817.3	250.9
33	2851.4	411.3 *	2817.3	250.9	2817.3	250.9

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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----- EXHAUST CLOUD -----

CHEMICAL SPECIES = HCL

MET. LAYER NO.	TOP OF LAYER (METERS)	LAYER SOURCE STRENGTH (GRAMS)	CLOUD UPDRAFT VELOCITY (M/S)	CLOUD RADIUS (METERS)	STD. DEVIATION ALONGWIND (METERS)	MATERIAL DIST. CROSSWIND (METERS)
1	13.4	0.00000E+00	16.2	0.0	0.0	0.0
2	26.8	0.00000E+00	18.7	0.0	0.0	0.0
3	40.2	0.00000E+00	19.0	0.0	0.0	0.0
4	53.6	0.00000E+00	18.5	0.0	0.0	0.0
5	76.7	0.00000E+00	17.1	0.0	0.0	0.0
6	99.8	0.00000E+00	15.7	0.0	0.0	0.0
7	122.8	0.00000E+00	14.3	0.0	0.0	0.0
8	181.9	0.00000E+00	11.6	0.0	0.0	0.0
9	240.9	0.00000E+00	9.8	0.0	0.0	0.0
10	299.9	0.00000E+00	8.6	0.0	0.0	0.0
11	389.7	0.00000E+00	7.2	0.0	0.0	0.0
12	479.6	0.00000E+00	6.2	0.0	0.0	0.0
13	569.4	2.55996E+04	5.5	57.8	27.0	27.0
14	604.7	5.76814E+04	5.3	357.6	166.6	166.6
15	784.9	7.57617E+05	4.4	576.6	268.7	268.7
16	909.5	9.14410E+05	3.9	758.9	353.6	353.6
17	944.6	3.05188E+05	3.7	825.8	384.8	384.8
18	1032.4	8.43722E+05	3.4	868.0	404.5	404.5
19	1214.3	2.03664E+06	2.7	937.9	437.1	437.1
20	1473.1 *	3.38134E+06	0.0	997.6	464.9	464.9
21	1519.1 *	9.70935E+05	0.0	1004.6	468.1	468.1
22	1671.5 *	3.12873E+06	0.0	994.6	463.5	463.5
23	1823.9 *	2.92277E+06	0.0	956.1	445.5	445.5
24	1882.7 *	1.05246E+06	0.0	911.4	424.7	424.7
25	1941.3 *	9.96597E+05	0.0	879.2	409.7	409.7
26	2021.1 *	1.26867E+06	0.0	833.5	388.4	388.4
27	2128.7 *	1.51950E+06	0.0	755.7	352.1	352.1
28	2168.0 *	4.94761E+05	0.0	678.1	316.0	316.0
29	2222.3 *	6.24670E+05	0.0	618.5	288.2	288.2
30	2276.6 *	5.53264E+05	0.0	535.2	249.4	249.4
31	2433.5 *	1.18010E+06	0.0	282.6	131.7	131.7
32	2555.7 *	7.55028E+05	0.0	199.9	93.2	93.2
33	2851.4 *	1.74695E+06	0.0	199.9	93.2	93.2

* - INDICATES CLOUD STABILIZATION TIME WAS USED

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****

----- CLOUD STABILIZATION -----

CALCULATION HEIGHT	(METERS)	0.00
STABILIZATION HEIGHT	(METERS)	1459.34
STABILIZATION TIME	(SECS)	411.32
FIRST MIXING LAYER HEIGHT-	(METERS)	TOP = 1882.75
		BASE= 0.00
SECOND SELECTED LAYER HEIGHT-	(METERS)	TOP = 2851.40
		BASE= 1882.75
SIGMAR(AZ) AT THE SURFACE	(DEGREES)	7.4561
SIGMER(EL) AT THE SURFACE	(DEGREES)	4.9445

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
1	4.03	1.41	43.50	7.00	5.9462	4.3792
2	5.21	1.41	50.50	7.00	4.1491	3.6863
3	6.62	1.41	57.50	7.00	3.7116	3.4879
4	8.04	1.41	64.50	7.00	3.4616	3.3687
5	8.66	-0.17	68.00	0.00	3.2828	3.2619
6	8.49	-0.17	68.00	0.00	3.1621	3.1621
7	8.32	-0.17	68.00	0.00	3.0890	3.0890
8	8.15	0.17	67.83	-0.33	3.0224	3.0224
9	7.97	-0.17	67.50	-0.33	2.9523	2.9523
10	7.80	-0.17	67.17	-0.33	2.8729	2.8729
11	7.63	0.17	67.50	1.00	2.7753	2.7753
12	7.46	0.17	68.50	1.00	2.6685	2.6685
13	7.29	0.17	69.50	1.00	2.5779	2.5779
14	7.20	0.00	70.00	0.00	2.4766	2.4766
15	7.20	0.00	71.00	2.00	2.3219	2.3219
16	7.02	0.36	73.00	2.00	2.1839	2.1839
17	6.76	0.15	74.00	0.00	2.0999	2.0999
18	6.69	0.00	74.50	1.00	1.9832	1.9832
19	6.61	-0.15	74.00	-2.00	1.7720	1.7720
20	6.61	0.15	70.00	-6.00	1.5503	1.5503
21	6.71	0.05	66.50	-1.00	1.4007	1.4007
22	6.96	0.44	64.00	-4.00	1.2512	1.2512
23	7.40	0.44	60.00	-4.00	1.0978	1.0978
24	8.18	1.13	56.00	-4.00	1.0175	1.0175
25	10.03	2.57	53.50	-1.00	1.0000	1.0000
26	11.57	0.51	52.50	-1.00	1.0000	1.0000
27	11.99	0.31	52.00	0.00	1.0000	1.0000
28	12.24	0.21	52.00	0.00	1.0000	1.0000
29	12.35	0.00	52.00	0.00	1.0000	1.0000
30	12.35	0.00	52.50	1.00	1.0000	1.0000

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****

----- CALCULATED METEOROLOGICAL LAYER PARAMETERS -----

MET. LAYER NO.	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIRECTION (DEG)	WIND DIRECTION SHEAR (DEG)	SIGMA OF AZI ANG (DEG)	SIGMA OF ELE ANG (DEG)
31	12.35	0.00	55.00	4.00	1.0000	1.0000
32	12.35	0.00	58.00	2.00	1.0000	1.0000
33	12.35	0.00	61.50	5.00	1.0000	1.0000

ALTITUDE RANGE USED IN COMPUTING TRANSITION LAYER AVERAGES
IS   0.0 TO 2433.5 METERS.

TRANSITION LAYER NUMBER- 1

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	1882.75	300.96	8.75		54.00		1.0000	1.0000
LAYER-			7.13	0.67	68.13	5.49	2.0831	2.0670
BOTTOM-	0.00	298.17	3.09		40.00		7.4561	4.9445

TRANSITION LAYER NUMBER- 2

VALUE AT	HEIGHT (METERS)	TEMP. (DEG K)	WIND SPEED (M/SEC)	WIND SPEED SHEAR (M/SEC)	WIND DIR. (DEG)	WIND DIR. SHEAR (DEG)	SIGMA AZI. (DEG)	SIGMA ELE. (DEG)
TOP-	2851.40	308.30	12.35		64.00		1.0000	1.0000
LAYER-			11.91	0.96	53.14	1.89	1.0000	1.0000
BOTTOM-	1882.75	300.96	8.75		54.00		1.0000	1.0000

                    ----- MAXIMUM CENTERLINE CALCULATIONS -----

                   ** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

                    CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
                      DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
                  CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN- TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
7000.2983	248.6619	0.0028	9.7529	16.3470
8000.2954	248.6252	0.0180	12.0681	21.3394
9000.2275	248.5401	0.0525	14.3792	23.7036
10000.2178	248.5111	0.1046	16.6863	26.0534
11000.4932	248.6754	0.1684	18.9900	28.4049
12000.3418	248.5651	0.2372	21.2906	30.7582
13000.4912	248.6309	0.3056	23.5883	33.1132
14000.3770	248.5535	0.3701	25.8835	35.4699
15000.6123	248.6503	0.4293	28.1765	37.8281
16000.5176	248.5936	0.4823	30.4674	40.1880
17000.4375	248.5435	0.5294	32.7566	42.5493
18000.7852	248.6682	0.5711	35.0443	44.9122
19000.7148	248.6297	0.6079	37.3305	47.2765
20000.6504	248.5951	0.6402	39.6155	49.6422
21000.5938	248.5638	0.6682	41.8994	52.0093
22000.5430	248.5353	0.6922	44.1823	54.3777
23000.4961	248.5093	0.7123	46.4643	56.7474
24000.4551	248.4855	0.7288	48.7455	59.1182
25000.4160	248.4636	0.7418	51.0260	61.4903
26000.3828	248.4433	0.7515	53.3058	63.8635
27000.3496	248.4246	0.7580	55.5851	66.2378
28000.3203	248.4072	0.7616	57.8638	68.6132
29000.2949	248.3910	0.7625	60.1420	70.9895
30000.2695	248.3759	0.7608	62.4199	73.3669
31000.2480	248.3617	0.7568	64.6973	75.7451
32000.2266	248.3484	0.7508	66.9743	78.1243
33000.2070	248.3360	0.7429	69.2510	80.5043
34000.1914	248.3243	0.7334	71.5274	82.8852
35000.1719	248.3132	0.7224	73.8036	85.2668
36000.1602	248.3028	0.7103	76.0794	87.6492
37000.1445	248.2929	0.6972	78.3551	90.0323
38000.1328	248.2835	0.6833	80.6305	92.4162
39000.1211	248.2746	0.6687	82.9057	94.8007
40000.1094	248.2662	0.6537	85.1807	97.1858
41000.0977	248.2582	0.6383	87.4555	99.5715

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****

----- MAXIMUM CENTERLINE CALCULATIONS -----

** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	PEAK CONCEN-TRATION (PPM)	CLOUD ARRIVAL TIME (MIN)	CLOUD DEPARTURE TIME (MIN)
42000.0898	248.2505	0.6226	89.7302	101.9579
43000.0781	248.2433	0.6069	92.0047	104.3448
44000.5586	248.4211	0.5911	94.2791	106.7322
45000.5430	248.4147	0.5755	96.5533	109.1202
46000.5313	248.4085	0.5599	98.8275	111.5087
47000.5195	248.4027	0.5446	101.1015	113.8976
48000.5117	248.3970	0.5295	103.3753	116.2870
49000.5000	248.3917	0.5147	105.6491	118.6768
50000.4883	248.3865	0.5003	107.9228	121.0671
51000.4805	248.3815	0.4862	110.1964	123.4578
52000.4727	248.3767	0.4724	112.4679	125.8488
53000.4609	248.3721	0.4591	114.7393	128.2402
54000.4531	248.3677	0.4461	117.0108	130.6320
55000.4453	248.3634	0.4336	119.2822	133.0242
56000.4375	248.3593	0.4214	121.5536	135.4166
57000.4297	248.3553	0.4097	123.8250	137.8094
58000.4219	248.3515	0.3983	126.0965	140.2025
59000.4141	248.3478	0.3874	128.3679	142.5959
60000.4102	248.3442	0.3768	130.6393	144.9896

	RANGE	BEARING
0.762 IS THE MAXIMUM PEAK CONCENTRATION	29000.3	248.4

                    ----- MAXIMUM CENTERLINE CALCULATIONS -----

              ** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

                 CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
                  DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
              CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

| | | 60.0 MIN. MEAN | CLOUD | CLOUD |
RANGE FROM PAD (METERS)	BEARING FROM PAD (DEGREES)	CONCEN- TRATION (PPM)	ARRIVAL TIME (MIN)	DEPARTURE TIME (MIN)
9000.4150	248.6833	0.0009	14.3792	23.7036
10000.4229	248.6594	0.0022	16.6863	26.0534
11000.4932	248.6754	0.0042	18.9900	28.4049
12000.6328	248.7213	0.0065	21.2906	30.7582
13000.4912	248.6309	0.0091	23.5883	33.1132
14000.7236	248.7152	0.0119	25.8835	35.4699
15000.6123	248.6503	0.0146	28.1765	37.8281
16000.5176	248.5936	0.0173	30.4674	40.1880
17000.8672	248.7112	0.0199	32.7566	42.5493
18000.7852	248.6682	0.0224	35.0443	44.9122
19000.7148	248.6297	0.0247	37.3305	47.2765
20000.6504	248.5951	0.0269	39.6155	49.6422
21000.5938	248.5638	0.0290	41.8994	52.0093
22000.5430	248.5353	0.0310	44.1823	54.3777
23000.4961	248.5093	0.0327	46.4643	56.7474
24000.4551	248.4855	0.0344	48.7455	59.1182
25000.4160	248.4636	0.0358	51.0260	61.4903
26000.3828	248.4433	0.0371	53.3058	63.8635
27000.3496	248.4246	0.0383	55.5851	66.2378
28000.3203	248.4072	0.0392	57.8638	68.6132
29000.2949	248.3910	0.0401	60.1420	70.9895
30000.2695	248.3759	0.0408	62.4199	73.3669
31000.2480	248.3617	0.0413	64.6973	75.7451
32000.2266	248.3484	0.0417	66.9743	78.1243
33000.2070	248.3360	0.0420	69.2510	80.5043
34000.1914	248.3243	0.0422	71.5274	82.8852
35000.1719	248.3132	0.0423	73.8036	85.2668
36000.1602	248.3028	0.0423	76.0794	87.6492
37000.1445	248.2929	0.0422	78.3551	90.0323
38000.1328	248.2835	0.0421	80.6305	92.4162
39000.1211	248.2746	0.0419	82.9057	94.8007
40000.1094	248.2662	0.0416	85.1807	97.1858
41000.0977	248.2582	0.0412	87.4555	99.5715
42000.0898	248.2505	0.0409	89.7302	101.9579

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        ****

                ----- MAXIMUM CENTERLINE CALCULATIONS -----

            ** DECAY COEFFICIENT (1/SEC) = 0.00000E+00 **

                CONCENTRATION OF HCL AT A HEIGHT OF 0.0 METERS
                DOWNWIND FROM A TITAN IVB SRMU NORMAL LAUNCH
            CALCULATIONS APPLY TO THE LAYER BETWEEN 0.0 AND 1882.7 METERS

| | | 60.0 MIN. MEAN CONCEN- | CLOUD ARRIVAL | CLOUD DEPARTURE |
| RANGE FROM PAD | BEARING FROM PAD | TRATION | TIME | TIME |
(METERS)	(DEGREES)	(PPM)	(MIN)	(MIN)
43000.0781	248.2433	0.0405	92.0047	104.3448
44000.5586	248.4211	0.0400	94.2791	106.7322
45000.5430	248.4147	0.0396	96.5533	109.1202
46000.5313	248.4085	0.0391	98.8275	111.5087
47000.5195	248.4027	0.0386	101.1015	113.8976
48000.5117	248.3970	0.0381	103.3753	116.2870
49000.5000	248.3917	0.0375	105.6491	118.6768
50000.4883	248.3865	0.0370	107.9228	121.0671
51000.4805	248.3815	0.0365	110.1964	123.4578
52000.4727	248.3767	0.0360	112.4679	125.8488
53000.4609	248.3721	0.0355	114.7393	128.2402
54000.4531	248.3677	0.0349	117.0108	130.6320
55000.4453	248.3634	0.0344	119.2822	133.0242
56000.4375	248.3593	0.0339	121.5536	135.4166
57000.4297	248.3553	0.0334	123.8250	137.8094
58000.4219	248.3515	0.0329	126.0965	140.2025
59000.4141	248.3478	0.0325	128.3679	142.5959
60000.4102	248.3442	0.0320	130.6393	144.9896

                                                        RANGE   BEARING

        0.042 IS THE MAXIMUM 60.0 MIN. MEAN CONCENTRATION   35000.2   248.3

*** REEDM HAS TERMINATED

Appendix B – Meteorological Data for the #B33 Mission

This Appendix contains three types of meteorological data recorded on and near CCAS before and after the #B33 launch, which occurred at 0443 EDT (0843Z) on 15 October 1997.

Rawinsonde Data

These data were collected by a rawinsonde balloon launched at 0803Z (T-40 min) from CCAS.

915 MHz Doppler Radar Data

These data were collected by five 915 MHz Doppler radars: two on CCAS, two on KSC, and one on the mainland. The data are averaged over 15 minutes. Data for 0835Z, 0850Z and 0905Z are presented.

Meteorological Tower Data

These data were collected by the network of range meteorological towers located on and near CCAS. The data are averaged over five minutes. Data are taken at the elevation Z (ft) above tower base, and includes wind direction (DIR), speed (SPD in knots), temperature (T in °F). Data for 0840Z, 0850Z, and 0900Z are presented.

T-0.70h Rawinsonde Data for the B-33 Mission

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RS012880803
TEST NBR A0454 W6                        4470
RAWINSONDE MSS/MSS
CAPE CANAVERAL AFS, FLORIDA
0803Z  15 OCT 97
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ALT GEOMFT	DIR DEG	SPD KTS	SHR /SEC	TEMP DEG C	DPT DEG C	PRESS MBS	RH PCT	ABHUM G/M3	DENSITY G/M3	I/R N	V/S KTS	VPS MBS	PW MM
16	40	6.0	.000	23.9	18.0	1014.10	70	15.09	1180.14	352	674	20.68	0
1000	67	15.0	.017	22.5	16.2	980.01	68	13.55	1146.64	336	673	18.48	4
2000	70	14.0	.002	19.2	15.9	946.23	81	13.38	1119.28	330	669	18.06	8
3000	74	13.3	.002	16.1	14.8	913.25	92	12.60	1092.44	320	665	16.82	12
4000	73	12.7	.001	14.0	12.3	881.11	89	10.80	1062.44	303	663	14.31	16
5000	66	13.1	.003	11.7	10.0	849.87	90	9.39	1033.78	288	660	12.34	19
6000	58	14.8	.004	9.6	7.4	819.50	86	7.91	1004.87	273	657	10.32	21
7000	52	23.6	.015	9.1	6.4	790.05	84	7.41	970.77	262	656	9.65	24
8000	57	24.0	.004	8.5	-4.8	761.59	38	3.31	939.89	230	655	4.30	25
9000	62	24.0	.004	7.4	-10.7	734.02	26	2.09	910.21	216	653	2.71	26
10000	67	22.7	.004	5.9	-9.4	707.34	32	2.33	881.76	211	652	3.00	27
11000	68	18.0	.008	3.2	-10.0	681.42	37	2.24	857.64	205	649	2.86	27
12000	64	11.5	.011	4.2	-17.1	656.38	20	1.25	823.85	191	649	1.60	28
13000	53	6.9	.008	3.0	-17.6	632.25	20	1.20	796.83	185	648	1.53	28
14000	32	5.2	.005	1.7	-18.6	608.89	20	1.11	771.12	179	647	1.40	28
15000	21	5.9	.002	-.1	-19.9	586.28	21	1.00	747.37	173	644	1.25	29
16000	22	7.0	.002	-2.2	-21.5	564.36	21	.87	725.17	167	642	1.09	29
17000	23	7.1	.000	-4.7	-23.2	543.07	22	.76	704.39	162	639	.94	29
18000	22	5.7	.002	-7.4	-25.2	522.39	22	.64	684.40	157	636	.79	30
19000	20	3.7	.003	-9.6	-26.8	502.32	23	.56	663.61	152	633	.68	30.
20000	32	3.0	.002	-11.5	-28.8	482.88	22	.47	642.69	146	631	.57	30
21000	76	2.9	.004	-13.9	-30.1	464.05	24	.41	623.29	142	628	.50	30
22000	116	4.3	.005	-16.5	-31.8	445.76	25	.36	604.93	137	625	.42	30
23000	116	5.2	.001	-19.0	-33.7	428.04	26	.30	586.48	133	622	.35	30
24000	86	5.3	.005	-21.8	-35.8	410.84	27	.24	569.32	129	618	.28	30
25000	48	5.2	.006	-24.3	-37.9	394.15	27	.20	551.60	124	615	.23	30
26000	360	5.7	.008	-26.9	-40.1	378.00	27	.16	534.58	120	612	.18	30
27000	332	6.9	.006	-29.1	-41.9	362.35	27	.13	517.18	116	609	.15	30
28000	320	8.0	.003	-30.7	-43.6	347.24	27	.11	498.86	112	607	.12	30
29000	312	11.7	.007	-32.6	-45.1	332.65	27	.10	481.74	108	605	.11	31
30000	317	16.4	.008	-32.9	-44.3	318.61	31	.10	461.97	104	604	.12	31
31000	324	21.0	.009	-35.1	-43.0	305.12	44	.12	446.42	100	601	.13	31
32000	324	21.9	.001	-37.6	-44.2	292.06	50	.11	431.97	97	598	.12	31
33000	321	20.6	.003	-40.0	-47.2	279.43	45	.08	417.46	94	595	.08	31
34000	317	18.0	.005	-42.5	-50.1	267.23	42	.06	403.54	90	592	.06	31
35000	314	15.2	.005	-45.5	-53.0	255.42	42	.04	390.88	87	588	.04	31
36000	310	13.3	.004	-48.2	-55.3	244.00	43	.03	377.83	84	585	.03	31
37000	305	12.9	.002	-51.1	-57.9	232.95	43	.02	365.42	82	581	.02	31
38000	300	14.0	.003	-51.9	-58.8	222.31	42	.02	349.96	78	580	.02	31
39000	290	15.7	.005	-53.9	-61.0	212.10	40	.02	336.97	75	577	.02	31
40000	288	19.2	.006	-55.8	-63.0	202.27	40	.01	324.23	72	575	.01	31
41000	290	23.7	.008	-57.5	-64.6	192.83	39	.01	311.46	69	572	.01	31
42000	287	27.6	.007	-58.7	-65.8	183.78	39	.01	298.50	67	571	.01	31
43000	275	27.2	.009	-60.5	99.9	175.09	999	99.99	286.87	64	568	.00	999
44000	269	27.6	.005	-62.9	99.9	166.72	999	99.99	276.21	62	565	.00	999
45000	271	29.8	.004	-64.9	99.9	158.67	999	99.99	265.41	59	563	.00	999

```
46000 279  31.4 .007 -65.5  99.9  150.97 999 99.99  253.30  56 562  .00999
47000 285  28.6 .007 -66.2  99.9  143.62 999 99.99  241.75  54 561  .00999
48000 284  21.4 .012 -66.8  99.9  136.61 999 99.99  230.61  51 560  .00999
49000 270  15.7 .012 -68.0  99.9  129.92 999 99.99  220.60  49 558  .00999
50000 256  14.0 .007 -70.2  99.9  123.49 999 99.99  212.01  47 555  .00999
51000 254  15.1 .002 -71.0  99.9  117.34 999 99.99  202.25  45 554  .00999
52000 260  17.4 .005 -71.9  99.9  111.48 999 99.99  193.01  43 553  .00999
53000 265  18.3 .003 -72.4  99.9  105.89 999 99.99  183.71  41 552  .00999
54000 268  17.3 .002 -71.9  99.9  100.58 999 99.99  174.11  39 553  .00999
55000 265  14.1 .006 -73.4  99.9   95.52 999 99.99  166.60  37 551  .00999
56000 258  10.2 .007 -73.9  99.9   90.69 999 99.99  158.60  35 550  .00999
57000 257   7.2 .005 -73.1  99.9   86.11 999 99.99  149.97  33 551  .00999
58000 256   5.8 .002 -72.4  99.9   81.79 999 99.99  141.95  32 552  .00999
59000 257   5.8 .000 -71.2  99.9   77.69 999 99.99  134.02  30 554  .00999
60000 246   4.3 .003 -70.8  99.9   73.83 999 99.99  127.13  28 554  .00999
61000 171   3.4 .008 -69.9  99.9   70.16 999 99.99  120.24  27 556  .00999
62000 135   6.4 .007 -70.5  99.9   66.68 999 99.99  114.63  26 555  .00999
63000 114   6.9 .004 -69.9  99.9   63.37 999 99.99  108.65  24 556  .00999
64000  89   8.4 .006 -68.9  99.9   60.24 999 99.99  102.77  23 557  .00999
65000  82  10.4 .004 -64.7  99.9   57.30 999 99.99   95.77  21 563  .00999
66000  96  12.6 .006 -62.7  99.9   54.54 999 99.99   90.31  20 565  .00999
67000 116  12.2 .008 -62.4  99.9   51.93 999 99.99   85.86  19 566  .00999
68000 137   9.9 .008 -61.0  99.9   49.46 999 99.99   81.20  18 568  .00999
69000 194   5.9 .014 -58.0  99.9   47.13 999 99.99   76.32  17 572  .00999
70000 258   5.0 .010 -57.5  99.9   44.92 999 99.99   72.57  16 572  .00999
71000 308   6.1 .008 -57.6  99.9   42.82 999 99.99   69.21  15 572  .00999
72000 345   6.3 .007 -57.4  99.9   40.82 999 99.99   65.91  15 573  .00999
73000  33   5.3 .008 -57.1  99.9   38.92 999 99.99   62.75  14 573  .00999
74000  85   7.4 .010 -57.5  99.9   37.10 999 99.99   59.94  13 572  .00999
75000 110  11.1 .009 -56.2  99.9   35.37 999 99.99   56.81  13 574  .00999
76000 121  13.7 .006 -56.3  99.9   33.73 999 99.99   54.18  12 574  .00999
77000 127  13.2 .003 -56.2  99.9   32.16 999 99.99   51.64  12 574  .00999
78000 132  11.4 .003 -56.2  99.9   30.67 999 99.99   49.25  11 574  .00999
79000 119   7.7 .007 -54.2  99.9   29.25 999 99.99   46.54  10 577  .00999
80000  75   5.9 .009 -53.2  99.9   27.91 999 99.99   44.20  10 578  .00999
81000  45   9.2 .008 -53.0  99.9   26.63 999 99.99   42.14   9 578  .00999
82000  45  12.0 .005 -55.1  99.9   25.41 999 99.99   40.59   9 576  .00999
83000  64  13.0 .007 -55.6  99.9   24.23 999 99.99   38.80   9 575  .00999
84000  84  14.5 .009 -54.2  99.9   23.12 999 99.99   36.79   8 577  .00999
85000  98  17.3 .008 -53.8  99.9   22.05 999 99.99   35.03   8 577  .00999
86000 101  20.0 .005 -52.4  99.9   21.05 999 99.99   33.21   7 579  .00999
87000 101  22.7 .004 -50.7  99.9   20.09 999 99.99   31.46   7 581  .00999
88000  97  22.4 .003 -50.1  99.9   19.18 999 99.99   29.96   7 582  .00999
89000  89  22.2 .005 -49.8  99.9   18.32 999 99.99   28.57   6 583  .00999
90000  78  21.7 .007 -48.4  99.9   17.49 999 99.99   27.12   6 584  .00999
91000 999 999.0 .999 -48.0  99.9   16.71 999 99.99   25.85   6 585  .00999
```
TERMINATION   91256 GEOPFT   27815 GEOPM   16.1 MBS
TROPOPAUSE   52628 FEET   107.93 MB -72.5 C   99.9 C

MANDATORY LEVELS
```
GEOPFT DIR KTS  TEMP   DPT PRESS   RH

  419  68  16  24.1  17.3 1000.0  66
 1884  70  14  19.6  15.9  950.0  79
 3403  75  13  15.1  13.8  900.0  92
 4987  66  13  11.7  10.1  850.0  90
 6647  52  23   9.5   4.8  800.0  73
 8401  59  24   7.9  -7.5  750.0  33
10260  68  22   5.1  -9.2  700.0  35
12236  62  10   3.9 -17.0  650.0  20
14359  26   5   1.0 -19.1  600.0  21
```

```
16634   23    7   -3.9  -22.8   550.0   21
19073   20    3   -9.8  -27.0   500.0   23
21712  110    4  -16.0  -31.3   450.0   25
24582   62    5  -23.4  -37.3   400.0   26
27737  322    8  -30.4  -43.3   350.0   27
31296  325   22  -36.0  -42.8   300.0   49
35359  312   14  -46.7  -54.0   250.0   43
40102  288   20  -56.1  -63.3   200.0   40
42860  275   27  -60.6   99.9   175.0  999
45962  280   31  -65.6   99.9   150.0  999
49572  258   14  -69.7   99.9   125.0  999
53894  268   17  -72.1   99.9   100.0  999
58183  256    6  -72.2   99.9    80.0  999
60780  168    4  -69.8   99.9    70.0  999
63791   88    9  -68.6   99.9    60.0  999
67460  131   11  -61.5   99.9    50.0  999
72071    4    6  -57.2   99.9    40.0  999
78060  129   10  -54.7   99.9    30.0  999
81903   50   12  -55.4   99.9    25.0  999
86610  101   23  -50.5   99.9    20.0  999
SIGNIFICANT LEVELS
GEOMFT DIR KTS   TEMP    DPT PRESS     IR   RH

   16   40    6   23.9   18.0 1014.1  352   70
  192   68   17   24.6   17.9 1007.9  349   66
 2591   72   14   17.3   15.4  926.6  325   89
 3115   74   13   15.7   14.6  909.5  319   93
 4849   67   13   11.9   10.6  854.5  291   92
 6193   54   17    9.1    7.4  813.7  272   89
 6385   53   22    9.8    4.3  808.0  260   68
 7129   52   24    8.9    7.0  786.3  263   88
 7307   52   24    8.8    7.1  781.2  262   89
 7485   53   24    9.3     .6  776.1  243   54
 7663   56   24    9.2   -2.7  771.1  235   43
 8225   58   24    8.1   -6.3  755.3  226   35
 9371   64   24    7.4  -12.0  724.0  212   24
10562   69   20    4.3   -9.0  692.7  209   37
11124   68   17    2.9  -10.3  678.3  204   37
11689   66   13    4.4  -17.2  664.1  193   19
13783   36    5    2.1  -18.4  613.9  180   20
15510   21    6   -1.1  -20.7  575.0  170   21
23555  102    5  -20.6  -34.8  418.4  130   26
25311   36    5  -25.0  -38.5  389.1  123   27
26842  333    7  -28.8  -41.7  364.8  117   27
29110  312   12  -32.8  -45.3  331.1  108   27
30411  320   18  -33.3  -43.8  313.0  102   33
31451  325   22  -36.1  -42.8  299.2   99   50
32696  322   21  -39.3  -46.3  283.2   95   47
37324  304   13  -51.9  -58.6  229.5   81   43
45229  273   31  -65.3   99.9  156.9   59  999
45751  277   32  -65.3   99.9  152.9   57  999
50184  254   14  -70.6   99.9  122.3   47  999
52628  264   18  -72.5   99.9  107.9   42  999
55326  263   13  -73.8   99.9   93.9   37  999
56514  256    9  -74.1   99.9   88.3   34  999
59545  254    5  -69.6   99.9   75.6   29  999
60253  240    4  -71.5   99.9   72.9   28  999
62598  125    7  -70.0   99.9   64.7   25  999
63941   90    8  -69.2   99.9   60.4   23  999
65122   83   11  -64.2   99.9   57.0   21  999
69086  201    6  -57.8   99.9   46.9   17  999
```

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73849  80    7 -57.8  99.9   37.4  13 999
78644 128    9 -54.1  99.9   29.7  11 999
80771  48    8 -52.5  99.9   26.9   9 999
82163  47   12 -55.4  99.9   25.2   9 999
87355 101   23 -50.0  99.9   19.8   7 999
91788 999  999 -49.2  99.9   16.1   6 999
TERMINATION
140 140
NNNN
```

915 Mhz Profiler information

Profiler Number	Name	Location	Latitude	Longitude
1	South Cape	CCAS	28.439372	80.575926
2	False Cape	CCAS	28.601539	80.589765
3	Merritt Island	KSC	28.561396	80.663205
4	Mosquito Lagoon	KSC	28.687737	80.719222
5	TiCo	Mainland	28.501873	80.794373

Header information

Name	Unit	Description
DAY	SYD	Year and Julian Day
HMS	HMS	Actual Time of Obs
IDN		Station ID Number
RZ	M	Altitude
DIR	DEG	Wind Direction
SSPD	MPS	Scaled Wind Speed
SHR	PS	Vertical Wind Shear

915 MHz Doppler Radar Data - 15 October 1997 0835Z

DAY	IDN	HMS	RZ	DIR	SSPD	SHR
97288	3	83526	117.0			
97288	3	83526	214.0			
97288	3	83526	311.0	63	7.30	
97288	3	83526	407.0	66	6.90	
97288	3	83526	504.0			
97288	3	83526	601.0	75	6.00	
97288	3	83526	697.0	66	8.10	
97288	3	83526	794.0	74	6.70	
97288	3	83526	891.0	74	6.90	
97288	3	83526	987.0	64	6.40	
97288	3	83526	1084.0	65	6.50	
97288	3	83526	1181.0	64	6.40	
97288	3	83526	1277.0	65	6.10	
97288	3	83526	1374.0	62	5.30	
97288	3	83526	1471.0	58	5.10	
97288	3	83526	1567.0	57	5.10	
97288	3	83526	1664.0	59	5.30	
97288	3	83526	1760.0	57	5.30	
97288	3	83526	1857.0	55	6.10	
97288	3	83526	1954.0			
97288	3	83526	2050.0			
97288	3	83526	2147.0			
97288	3	83526	2244.0			
97288	3	83526	2340.0	52	13.90	
97288	3	83526	2437.0			
97288	3	83526	2534.0			
97288	3	83526	2630.0	58	12.70	
97288	3	83526	2727.0	63	11.30	
97288	3	83526	2824.0	65	10.60	
97288	3	83526	2920.0	68	12.00	
97288	3	83526	3017.0	70	12.60	
97288	3	83526	3114.0	70	11.90	
97288	4	83508	117.0	47	6.80	
97288	4	83508	214.0	49	7.00	
97288	4	83508	311.0	55	6.70	
97288	4	83508	407.0			
97288	4	83508	504.0	52	6.50	
97288	4	83508	601.0	57	6.30	
97288	4	83508	697.0	61	6.50	
97288	4	83508	794.0	64	6.70	
97288	4	83508	891.0	65	6.30	
97288	4	83508	987.0	68	5.80	
97288	4	83508	1084.0	67	5.50	
97288	4	83508	1181.0	65	5.30	
97288	4	83508	1277.0	62	5.10	
97288	4	83508	1374.0	65	4.80	
97288	4	83508	1471.0	64	4.90	
97288	4	83508	1567.0	62	5.50	
97288	4	83508	1664.0	66	6.30	
97288	4	83508	1760.0	69	6.40	
97288	4	83508	1857.0	72	7.20	
97288	4	83508	1954.0	86	7.80	
97288	4	83508	2050.0			
97288	4	83508	2147.0			
97288	4	83508	2244.0			

97288	4	83508	2340.0	64	12.60
97288	4	83508	2437.0		
97288	4	83508	2534.0	60	11.30
97288	4	83508	2630.0	62	12.20
97288	4	83508	2727.0	72	11.10
97288	4	83508	2824.0	74	10.40
97288	4	83508	2920.0	74	11.10
97288	4	83508	3017.0	72	11.20
97288	4	83508	3114.0	72	11.10
97288	5	83533	117.0	43	4.70
97288	5	83533	214.0	62	5.30
97288	5	83533	311.0	64	6.00
97288	5	83533	407.0	66	7.10
97288	5	83533	504.0	71	6.60
97288	5	83533	601.0	68	7.90
97288	5	83533	697.0	67	8.00
97288	5	83533	794.0	68	6.70
97288	5	83533	891.0	74	7.30
97288	5	83533	987.0	75	6.40
97288	5	83533	1084.0	74	6.50
97288	5	83533	1181.0	72	6.60
97288	5	83533	1277.0	72	6.30
97288	5	83533	1374.0	72	5.80
97288	5	83533	1471.0		
97288	5	83533	1567.0	62	5.00
97288	5	83533	1664.0	67	6.50
97288	5	83533	1760.0	72	6.90
97288	5	83533	1857.0	72	7.40
97288	5	83533	1954.0	65	8.30
97288	5	83533	2050.0	56	10.10
97288	5	83533	2147.0	59	12.60
97288	5	83533	2244.0	60	14.10
97288	5	83533	2340.0		
97288	5	83533	2437.0	61	10.90
97288	5	83533	2534.0	62	11.80
97288	5	83533	2630.0	64	12.70
97288	5	83533	2727.0	70	12.50
97288	5	83533	2824.0	74	10.60
97288	5	83533	2920.0	73	11.00
97288	5	83533	3017.0	74	11.50
97288	5	83533	3114.0	74	11.90
97288	2	83536	117.0	71	7.10
97288	2	83536	214.0	71	7.10
97288	2	83536	311.0	72	7.00
97288	2	83536	407.0	70	7.30
97288	2	83536	504.0	61	7.30
97288	2	83536	601.0	61	7.50
97288	2	83536	697.0	64	7.20
97288	2	83536	794.0	66	6.90
97288	2	83536	891.0	60	6.90
97288	2	83536	987.0	57	7.00
97288	2	83536	1084.0	58	6.40
97288	2	83536	1181.0	58	6.30
97288	2	83536	1277.0	49	5.40
97288	2	83536	1374.0	42	4.40
97288	2	83536	1471.0	63	5.10
97288	2	83536	1567.0	35	3.40
97288	2	83536	1664.0	47	4.30

97288	2	83536	1760.0		
97288	2	83536	1857.0		
97288	2	83536	1954.0		
97288	2	83536	2050.0		
97288	2	83536	2147.0	48	7.60
97288	2	83536	2244.0		
97288	2	83536	2340.0		
97288	2	83536	2437.0		
97288	2	83536	2534.0	56	12.50
97288	2	83536	2630.0	54	13.40
97288	2	83536	2727.0	61	11.20
97288	2	83536	2824.0		
97288	2	83536	2920.0	67	11.20
97288	2	83536	3017.0	68	11.80
97288	2	83536	3114.0	61	11.90
97288	1	83529	117.0		
97288	1	83529	214.0	67	6.70
97288	1	83529	311.0	69	6.50
97288	1	83529	407.0	68	6.70
97288	1	83529	504.0	73	6.90
97288	1	83529	601.0	76	7.20
97288	1	83529	697.0	69	7.00
97288	1	83529	794.0	68	6.70
97288	1	83529	891.0	66	6.40
97288	1	83529	987.0	69	6.90
97288	1	83529	1084.0	71	6.70
97288	1	83529	1181.0	72	6.10
97288	1	83529	1277.0	74	5.50
97288	1	83529	1374.0	72	4.80
97288	1	83529	1471.0	74	3.70
97288	1	83529	1567.0	64	3.40
97288	1	83529	1664.0		
97288	1	83529	1760.0	59	6.00
97288	1	83529	1857.0		
97288	1	83529	1954.0		
97288	1	83529	2050.0		
97288	1	83529	2147.0	59	10.60
97288	1	83529	2244.0		
97288	1	83529	2340.0	51	11.50
97288	1	83529	2437.0		
97288	1	83529	2534.0	59	13.70
97288	1	83529	2630.0	60	13.10
97288	1	83529	2727.0	66	11.40
97288	1	83529	2824.0	69	10.90
97288	1	83529	2920.0	63	11.10
97288	1	83529	3017.0	63	11.60
97288	1	83529	3114.0	64	12.60

915 MHz Doppler Radar Data – 15 October 1997 0850Z

DAY	IDN	HMS	RZ	DIR	SSPD	SHR
97288	2	85000	117.0	64	5.90	
97288	2	85000	214.0	67	6.00	
97288	2	85000	311.0	62	6.20	
97288	2	85000	407.0	61	6.50	
97288	2	85000	504.0	65	7.30	
97288	2	85000	601.0	63	7.20	

97288	2	85000	697.0	65	7.40
97288	2	85000	794.0	64	7.40
97288	2	85000	891.0	58	7.00
97288	2	85000	987.0	59	6.70
97288	2	85000	1084.0	54	6.50
97288	2	85000	1181.0	62	6.10
97288	2	85000	1277.0	63	5.70
97288	2	85000	1374.0	59	5.50
97288	2	85000	1471.0	57	5.40
97288	2	85000	1567.0	52	5.30
97288	2	85000	1664.0	46	5.70
97288	2	85000	1760.0	42	6.40
97288	2	85000	1857.0	44	7.00
97288	2	85000	1954.0	56	8.30
97288	2	85000	2050.0	53	9.40
97288	2	85000	2147.0	56	9.70
97288	2	85000	2244.0		
97288	2	85000	2340.0	47	11.70
97288	2	85000	2437.0	47	12.00
97288	2	85000	2534.0	50	12.10
97288	2	85000	2630.0	54	13.30
97288	2	85000	2727.0	59	13.20
97288	2	85000	2824.0	62	10.70
97288	2	85000	2920.0	65	10.70
97288	2	85000	3017.0	66	11.70
97288	2	85000	3114.0	67	12.60
97288	5	85011	117.0	54	5.50
97288	5	85011	214.0	60	5.70
97288	5	85011	311.0	62	6.60
97288	5	85011	407.0	65	5.70
97288	5	85011	504.0	63	6.40
97288	5	85011	601.0	58	7.50
97288	5	85011	697.0	63	7.10
97288	5	85011	794.0	65	7.20
97288	5	85011	891.0	63	7.10
97288	5	85011	987.0	64	7.30
97288	5	85011	1084.0	67	6.50
97288	5	85011	1181.0	75	6.60
97288	5	85011	1277.0	73	6.10
97288	5	85011	1374.0	69	6.70
97288	5	85011	1471.0	68	6.70
97288	5	85011	1567.0		
97288	5	85011	1664.0	71	7.40
97288	5	85011	1760.0	72	6.70
97288	5	85011	1857.0	66	7.20
97288	5	85011	1954.0	60	6.30
97288	5	85011	2050.0	55	9.00
97288	5	85011	2147.0	62	9.90
97288	5	85011	2244.0	60	11.90
97288	5	85011	2340.0	58	13.40
97288	5	85011	2437.0		
97288	5	85011	2534.0	65	10.50
97288	5	85011	2630.0	65	11.90
97288	5	85011	2727.0	69	11.30
97288	5	85011	2824.0	74	10.10
97288	5	85011	2920.0	74	11.10
97288	5	85011	3017.0	74	11.40
97288	5	85011	3114.0	74	11.40

97288	4	85017	117.0		
97288	4	85017	214.0		
97288	4	85017	311.0		
97288	4	85017	407.0		
97288	4	85017	504.0		
97288	4	85017	601.0		
97288	4	85017	697.0		
97288	4	85017	794.0	66	6.30
97288	4	85017	891.0	55	6.80
97288	4	85017	987.0	61	6.10
97288	4	85017	1084.0	60	6.00
97288	4	85017	1181.0	64	5.30
97288	4	85017	1277.0	72	5.10
97288	4	85017	1374.0	70	5.00
97288	4	85017	1471.0	63	4.80
97288	4	85017	1567.0	51	4.40
97288	4	85017	1664.0	53	5.10
97288	4	85017	1760.0	57	6.00
97288	4	85017	1857.0	70	6.90
97288	4	85017	1954.0	70	7.90
97288	4	85017	2050.0	72	7.80
97288	4	85017	2147.0	67	9.80
97288	4	85017	2244.0		
97288	4	85017	2340.0	3	16.80
97288	4	85017	2437.0	50	14.50
97288	4	85017	2534.0		
97288	4	85017	2630.0	60	12.10
97288	4	85017	2727.0	60	12.80
97288	4	85017	2824.0	68	10.80
97288	4	85017	2920.0	71	10.50
97288	4	85017	3017.0	71	10.90
97288	4	85017	3114.0	71	10.90
97288	3	85020	117.0	53	6.40
97288	3	85020	214.0	58	6.90
97288	3	85020	311.0	59	6.40
97288	3	85020	407.0	60	6.30
97288	3	85020	504.0	61	6.30
97288	3	85020	601.0	58	6.70
97288	3	85020	697.0	53	6.50
97288	3	85020	794.0	53	6.60
97288	3	85020	891.0	60	6.70
97288	3	85020	987.0	57	6.80
97288	3	85020	1084.0	57	6.80
97288	3	85020	1181.0	59	6.30
97288	3	85020	1277.0	57	5.60
97288	3	85020	1374.0	68	6.00
97288	3	85020	1471.0	55	4.80
97288	3	85020	1567.0	32	3.80
97288	3	85020	1664.0	42	3.00
97288	3	85020	1760.0	41	3.90
97288	3	85020	1857.0	48	5.90
97288	3	85020	1954.0		
97288	3	85020	2050.0		
97288	3	85020	2147.0		
97288	3	85020	2244.0		
97288	3	85020	2340.0		
97288	3	85020	2437.0	52	10.50
97288	3	85020	2534.0	54	12.00

97288	3	85020	2630.0	57	13.20
97288	3	85020	2727.0	58	13.00
97288	3	85020	2824.0	60	11.00
97288	3	85020	2920.0	64	11.00
97288	3	85020	3017.0	67	11.80
97288	3	85020	3114.0	69	11.90
97288	1	85013	117.0		
97288	1	85013	214.0	64	4.30
97288	1	85013	311.0	65	5.30
97288	1	85013	407.0	68	5.30
97288	1	85013	504.0	75	7.70
97288	1	85013	601.0	66	7.50
97288	1	85013	697.0	66	7.90
97288	1	85013	794.0	70	7.70
97288	1	85013	891.0	63	6.50
97288	1	85013	987.0	60	6.40
97288	1	85013	1084.0	56	6.30
97288	1	85013	1181.0	51	6.10
97288	1	85013	1277.0		
97288	1	85013	1374.0	66	6.00
97288	1	85013	1471.0	73	5.20
97288	1	85013	1567.0	66	4.60
97288	1	85013	1664.0	61	4.80
97288	1	85013	1760.0	63	6.20
97288	1	85013	1857.0	49	6.60
97288	1	85013	1954.0	47	7.80
97288	1	85013	2050.0	48	8.40
97288	1	85013	2147.0	52	10.50
97288	1	85013	2244.0	53	12.90
97288	1	85013	2340.0		
97288	1	85013	2437.0		
97288	1	85013	2534.0	56	14.30
97288	1	85013	2630.0		
97288	1	85013	2727.0	59	11.30
97288	1	85013	2824.0	65	11.10
97288	1	85013	2920.0	68	11.80
97288	1	85013	3017.0	67	12.20
97288	1	85013	3114.0	60	11.10

915 MHz Doppler Radar Data – 15 October 1997 0905Z

DAY	IDN	HMS	RZ	DIR	SSPD	SHR
97288	5	90516	117.0	43	5.50	
97288	5	90516	214.0	43	6.20	
97288	5	90516	311.0			
97288	5	90516	407.0	60	8.50	
97288	5	90516	504.0			
97288	5	90516	601.0	62	8.20	
97288	5	90516	697.0	66	6.80	
97288	5	90516	794.0	65	7.00	
97288	5	90516	891.0	63	6.20	
97288	5	90516	987.0	64	6.30	
97288	5	90516	1084.0	64	6.40	
97288	5	90516	1181.0	65	6.60	
97288	5	90516	1277.0	69	6.40	
97288	5	90516	1374.0	67	6.40	
97288	5	90516	1471.0	70	6.80	
97288	5	90516	1567.0	64	6.30	

97288	5	90516	1664.0	63	6.50
97288	5	90516	1760.0	66	5.60
97288	5	90516	1857.0	67	6.10
97288	5	90516	1954.0	67	6.60
97288	5	90516	2050.0	68	8.10
97288	5	90516	2147.0	66	9.60
97288	5	90516	2244.0		
97288	5	90516	2340.0		
97288	5	90516	2437.0		
97288	5	90516	2534.0	64	11.70
97288	5	90516	2630.0	65	12.70
97288	5	90516	2727.0	67	13.00
97288	5	90516	2824.0	76	11.20
97288	5	90516	2920.0	77	11.30
97288	5	90516	3017.0	76	11.60
97288	5	90516	3114.0	76	12.00
97288	2	90525	117.0	48	6.50
97288	2	90525	214.0	47	6.90
97288	2	90525	311.0	54	6.10
97288	2	90525	407.0	51	6.50
97288	2	90525	504.0	50	7.00
97288	2	90525	601.0	60	7.40
97288	2	90525	697.0	61	7.10
97288	2	90525	794.0	64	6.70
97288	2	90525	891.0	63	6.70
97288	2	90525	987.0	69	7.20
97288	2	90525	1084.0	61	7.10
97288	2	90525	1181.0	61	6.40
97288	2	90525	1277.0	75	6.20
97288	2	90525	1374.0	81	6.20
97288	2	90525	1471.0	39	4.10
97288	2	90525	1567.0	39	3.60
97288	2	90525	1664.0	31	4.40
97288	2	90525	1760.0	53	5.80
97288	2	90525	1857.0	59	6.50
97288	2	90525	1954.0		
97288	2	90525	2050.0		
97288	2	90525	2147.0		
97288	2	90525	2244.0		
97288	2	90525	2340.0		
97288	2	90525	2437.0		
97288	2	90525	2534.0	49	13.80
97288	2	90525	2630.0		
97288	2	90525	2727.0	49	12.80
97288	2	90525	2824.0	60	11.60
97288	2	90525	2920.0	61	9.90
97288	2	90525	3017.0	63	10.70
97288	2	90525	3114.0	65	12.10
97288	3	90534	117.0	72	6.00
97288	3	90534	214.0	60	7.20
97288	3	90534	311.0	82	6.90
97288	3	90534	407.0		
97288	3	90534	504.0		
97288	3	90534	601.0	56	7.20
97288	3	90534	697.0	60	7.10
97288	3	90534	794.0	61	6.80
97288	3	90534	891.0	59	6.90
97288	3	90534	987.0	59	6.70

97288	3	90534	1084.0	55	6.70
97288	3	90534	1181.0	50	6.70
97288	3	90534	1277.0	42	6.40
97288	3	90534	1374.0	35	6.00
97288	3	90534	1471.0	32	5.90
97288	3	90534	1567.0	34	5.80
97288	3	90534	1664.0	37	6.30
97288	3	90534	1760.0	44	7.00
97288	3	90534	1857.0	51	7.30
97288	3	90534	1954.0	53	7.70
97288	3	90534	2050.0	59	8.30
97288	3	90534	2147.0		
97288	3	90534	2244.0		
97288	3	90534	2340.0		
97288	3	90534	2437.0		
97288	3	90534	2534.0		
97288	3	90534	2630.0	53	12.50
97288	3	90534	2727.0		
97288	3	90534	2824.0	59	10.70
97288	3	90534	2920.0	64	10.10
97288	3	90534	3017.0	67	11.10
97288	3	90534	3114.0	71	11.60
97288	1	90519	117.0	53	6.40
97288	1	90519	214.0		
97288	1	90519	311.0	60	5.80
97288	1	90519	407.0	59	6.90
97288	1	90519	504.0	61	7.00
97288	1	90519	601.0	62	7.00
97288	1	90519	697.0	60	6.60
97288	1	90519	794.0	58	5.70
97288	1	90519	891.0	57	6.20
97288	1	90519	987.0		
97288	1	90519	1084.0	60	5.80
97288	1	90519	1181.0	56	5.70
97288	1	90519	1277.0	60	5.90
97288	1	90519	1374.0	58	4.70
97288	1	90519	1471.0	67	4.50
97288	1	90519	1567.0	64	4.40
97288	1	90519	1664.0	70	5.30
97288	1	90519	1760.0	70	6.00
97288	1	90519	1857.0	63	6.20
97288	1	90519	1954.0	60	6.50
97288	1	90519	2050.0	59	7.90
97288	1	90519	2147.0	64	10.00
97288	1	90519	2244.0		
97288	1	90519	2340.0	60	10.60
97288	1	90519	2437.0	66	12.00
97288	1	90519	2534.0	66	11.90
97288	1	90519	2630.0	68	11.50
97288	1	90519	2727.0	68	12.20
97288	1	90519	2824.0	67	11.90
97288	1	90519	2920.0	69	11.60
97288	1	90519	3017.0	66	12.20
97288	1	90519	3114.0	67	12.20
97288	4	90525	117.0	45	7.20
97288	4	90525	214.0	49	6.70
97288	4	90525	311.0	50	7.10
97288	4	90525	407.0	54	6.10

97288	4	90525	504.0	53	6.80
97288	4	90525	601.0	51	7.30
97288	4	90525	697.0	58	6.90
97288	4	90525	794.0	62	6.70
97288	4	90525	891.0	61	6.30
97288	4	90525	987.0	63	6.60
97288	4	90525	1084.0	65	6.10
97288	4	90525	1181.0	69	5.60
97288	4	90525	1277.0	73	4.70
97288	4	90525	1374.0	68	4.40
97288	4	90525	1471.0	65	4.50
97288	4	90525	1567.0	68	4.70
97288	4	90525	1664.0	68	5.80
97288	4	90525	1760.0	71	7.00
97288	4	90525	1857.0	73	8.30
97288	4	90525	1954.0	75	9.70
97288	4	90525	2050.0		
97288	4	90525	2147.0		
97288	4	90525	2244.0	358	15.90
97288	4	90525	2340.0		
97288	4	90525	2437.0	354	17.80
97288	4	90525	2534.0		
97288	4	90525	2630.0	58	11.80
97288	4	90525	2727.0	62	12.40
97288	4	90525	2824.0	68	12.00
97288	4	90525	2920.0	68	11.80
97288	4	90525	3017.0	66	11.70
97288	4	90525	3114.0	68	11.50

Meteorological Tower Data – 15 October 1997   0840Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97288	84000	28.4338	80.5734	6			75		1
97288	84000	28.4338	80.5734	12	48	1.0			1
97288	84000	28.4338	80.5734	54	61	7.0	77		1
97288	84000	28.4443	80.5621	6			76	66	2
97288	84000	28.4443	80.5621	12	58	1.9			2
97288	84000	28.4443	80.5621	54	63	6.0	77	65	2
97288	84000	28.4443	80.5621	90	67	8.0			2
97288	84000	28.4443	80.5621	162	70	9.9			2
97288	84000	28.4443	80.5621	204	67	12.1	78	64	2
97288	84000	28.4443	80.5621	6			76	65	2
97288	84000	28.4443	80.5621	12	55	1.9			2
97288	84000	28.4443	80.5621	54	62	6.0	77	66	2
97288	84000	28.4443	80.5621	90	63	8.0			2
97288	84000	28.4443	80.5621	162	68	9.9			2
97288	84000	28.4443	80.5621	204	66	11.1	78	69	2
97288	84000	28.4598	80.5267	6			78		3
97288	84000	28.4598	80.5267	12	73	9.9			3
97288	84000	28.4598	80.5267	54	73	11.1			3
97288	84000	28.4466	80.5652	6					17
97288	84000	28.7435	80.7005	6			80	71	19
97288	84000	28.7435	80.7005	54	52	11.1			19
97288	84000	28.7975	80.7378	6			80	69	22
97288	84000	28.7975	80.7378	54	67	11.1			22
97288	84000	28.4721	80.5393	6					36
97288	84000	28.4721	80.5393	90	78	12.1			36
97288	84000	28.5622	80.5785	6					40
97288	84000	28.5622	80.5785	54	67	9.9			40
97288	84000	28.5836	80.5842	6					41
97288	84000	28.5836	80.5842	54	50	11.1			41
97288	84000	28.5130	80.5613	6			78	69	61
97288	84000	28.5130	80.5613	12	66	5.1			61
97288	84000	28.5130	80.5613	54	73	9.9	76	64	61
97288	84000	28.5130	80.5613	162	73	14.0			61
97288	84000	28.5130	80.5613	204	75	14.0	78	72	61
97288	84000	28.5130	80.5613	6			77	66	62
97288	84000	28.5130	80.5613	12	62	4.1			62
97288	84000	28.5130	80.5613	54	65	8.9	78	66	62
97288	84000	28.5130	80.5613	162	65	13.0			62
97288	84000	28.5130	80.5613	204	69	13.0	78	64	62
97288	84000	28.5358	80.5747	6			77		108
97288	84000	28.5358	80.5747	12	72	2.9			108
97288	84000	28.5358	80.5747	54	66	7.0	78		108
97288	84000	28.6141	80.6203	6			77		112
97288	84000	28.6141	80.6203	12	61	6.0			112
97288	84000	28.6141	80.6203	54	61	8.9	78		112
97288	84000	28.4048	80.6519	6					300
97288	84000	28.4048	80.6519	54					300
97288	84000	28.4600	80.5711	6			72		303
97288	84000	28.4600	80.5711	12	56	1.9			303
97288	84000	28.4600	80.5711	54	52	5.1	76		303
97288	84000	28.6027	80.6414	6			78		311
97288	84000	28.6027	80.6414	12	43	2.9			311
97288	84000	28.6027	80.6414	54	52	6.0	77		311
97288	84000	28.6105	80.6069	6					393
97288	84000	28.6105	80.6069	60	62	12.1	78	68	393

97288	84000	28.6057	80.6016	6			77	66	394
97288	84000	28.6057	80.6016	60	66	11.1	78	67	394
97288	84000	28.6294	80.6235	6					397
97288	84000	28.6294	80.6235	60	62	15.9	81	-43	397
97288	84000	28.6248	80.6182	6			77	67	398
97288	84000	28.6248	80.6182	60	56	11.1	78	68	398
97288	84000	28.4586	80.5923	6			72		403
97288	84000	28.4586	80.5923	12	59	1.9			403
97288	84000	28.4586	80.5923	54	55	6.0	78		403
97288	84000	28.6062	80.6739	6			73		412
97288	84000	28.6062	80.6739	12	21	1.9			412
97288	84000	28.6062	80.6739	54	42	5.1	76		412
97288	84000	28.6586	80.6998	6			74		415
97288	84000	28.6586	80.6998	12	39	1.9			415
97288	84000	28.6586	80.6998	54	49	5.1	76		415
97288	84000	28.7055	80.7265	6			78	68	418
97288	84000	28.7055	80.7265	54	49	8.0			418
97288	84000	28.7755	80.8043	6			77	69	421
97288	84000	28.7755	80.8043	54	62	4.1			421
97288	84000	28.5158	80.6400	6			75		506
97288	84000	28.5158	80.6400	12	48	1.9			506
97288	84000	28.5158	80.6400	54	65	5.1	77		506
97288	84000	28.5623	80.6694	6			70		509
97288	84000	28.5623	80.6694	12	17	1.0			509
97288	84000	28.5623	80.6694	54	36	4.1	75		509
97288	84000	28.5986	80.6817	6					511
97288	84000	28.5986	80.6817	30	35	4.1			511
97288	84000	28.6160	80.6930	6			72	67	512
97288	84000	28.6160	80.6930	30	37	4.1			512
97288	84000	28.6307	80.7027	6					513
97288	84000	28.6307	80.7027	30	40	5.1			513
97288	84000	28.6431	80.7482	6			69		714
97288	84000	28.6431	80.7482	12	10	1.0			714
97288	84000	28.6431	80.7482	54	39	5.1	75		714
97288	84000	28.4632	80.6702	6			66		803
97288	84000	28.4632	80.6702	12	335	0.0			803
97288	84000	28.4632	80.6702	54	23	1.9	73		803
97288	84000	28.5184	80.6962	6			75		805
97288	84000	28.5184	80.6962	12	337	0.0			805
97288	84000	28.5184	80.6962	54	30	1.9	73		805
97288	84000	28.7464	80.8707	6			69	67	819
97288	84000	28.7464	80.8707	54	322	1.9			819
97288	84000	28.4079	80.7604	6			67	66	1000
97288	84000	28.4079	80.7604	54	336	2.9			1000
97288	84000	28.5272	80.7742	6			78	71	1007
97288	84000	28.5272	80.7742	54	38	6.0			1007
97288	84000	28.6056	80.8248	6			69	67	1012
97288	84000	28.6056	80.8248	54	22	1.9			1012
97288	84000	28.5697	80.5864	6			77	68	1101
97288	84000	28.5697	80.5864	12	62	4.1			1101
97288	84000	28.5697	80.5864	54	61	8.0	78	66	1101
97288	84000	28.5697	80.5864	162	65	12.1			1101
97288	84000	28.5697	80.5864	204	63	13.0	78	65	1101
97288	84000	28.5697	80.5864	6			77	67	1102
97288	84000	28.5697	80.5864	12	64	2.9			1102
97288	84000	28.5697	80.5864	54	62	7.0	78	65	1102
97288	84000	28.5697	80.5864	162	58	12.1			1102
97288	84000	28.5697	80.5864	204	60	13.0	78	65	1102

97288	84000	28.4843	80.7856	6			67	66	1204
97288	84000	28.4843	80.7856	54	318	1.9			1204
97288	84000	28.6445	80.9034	6					1215
97288	84000	28.4114	80.9284	6			63	62	1500
97288	84000	28.4114	80.9284	54	339	4.1			1500
97288	84000	28.4475	80.8538	6					1502
97288	84000	28.4960	80.8843	6					1605
97288	84000	28.4960	80.8843	54					1605
97288	84000	28.5583	80.9132	6					1609
97288	84000	28.6173	80.9581	6			69	69	1612
97288	84000	28.6173	80.9581	54	339	5.1			1612
97288	84000	28.6762	80.9987	6			67	67	1617
97288	84000	28.6762	80.9987	54	16	4.1			1617
97288	84000	28.5231	81.0100	6			65	65	2008
97288	84000	28.5231	81.0100	54	337	2.9			2008
97288	84000	28.6489	81.0693	6			64	64	2016
97288	84000	28.6489	81.0693	54	340	1.0			2016
97288	84000	28.4417	81.0291	6					2202
97288	84000	28.4417	81.0291	54					2202
97288	84000	28.6256	80.6571	6			74	65	3131
97288	84000	28.6256	80.6571	12	57	1.0			3131
97288	84000	28.6256	80.6571	54	64	6.0	77	64	3131
97288	84000	28.6256	80.6571	162	65	8.9			3131
97288	84000	28.6256	80.6571	204	66	9.9	78	64	3131
97288	84000	28.6256	80.6571	295	64	11.1			3131
97288	84000	28.6256	80.6571	394	64	11.1			3131
97288	84000	28.6256	80.6571	492	58	11.1	76	64	3131
97288	84000	28.6256	80.6571	6			74	65	3132
97288	84000	28.6256	80.6571	12	56	1.0			3132
97288	84000	28.6256	80.6571	54	60	6.0	77	65	3132
97288	84000	28.6256	80.6571	162	63	9.9			3132
97288	84000	28.6256	80.6571	204	65	11.1	78	64	3132
97288	84000	28.6256	80.6571	295	62	11.1			3132
97288	84000	28.6256	80.6571	394	63	11.1			3132
97288	84000	28.6256	80.6571	492	64	9.9	76	63	3132
97288	84000	28.3932	80.8211	6			69	68	9001
97288	84000	28.3932	80.8211	54	346	1.9			9001
97288	84000	28.3382	80.7321	6			69	67	9404
97288	84000	28.3382	80.7321	54	353	1.9			9404

Meteorological Tower Data - 15 October 1997 0850Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97288	85000	28.4338	80.5734	6			75		1
97288	85000	28.4338	80.5734	12	37	1.0			1
97288	85000	28.4338	80.5734	54	57	7.0	77		1
97288	85000	28.4443	80.5621	6			75	66	2
97288	85000	28.4443	80.5621	12	51	1.9			2
97288	85000	28.4443	80.5621	54	61	6.0	77	65	2
97288	85000	28.4443	80.5621	90	68	8.0			2
97288	85000	28.4443	80.5621	162	71	9.9			2
97288	85000	28.4443	80.5621	204	68	12.1	78	65	2
97288	85000	28.4443	80.5621	6			75	65	2
97288	85000	28.4443	80.5621	12	51	1.9			2
97288	85000	28.4443	80.5621	54	59	6.0	77	66	2
97288	85000	28.4443	80.5621	90	64	8.0			2
97288	85000	28.4443	80.5621	162	69	9.9			2

97288	85000	28.4443	80.5621	204	66	11.1	77	69	2
97288	85000	28.4598	80.5267	6			78		3
97288	85000	28.4598	80.5267	12	75	9.9			3
97288	85000	28.4598	80.5267	54	73	12.1			3
97288	85000	28.4466	80.5652	6					17
97288	85000	28.7435	80.7005	6			80	70	19
97288	85000	28.7435	80.7005	54	42	13.0			19
97288	85000	28.7975	80.7378	6			80	69	22
97288	85000	28.7975	80.7378	54	61	11.1			22
97288	85000	28.4721	80.5393	6					36
97288	85000	28.4721	80.5393	90	77	13.0			36
97288	85000	28.5622	80.5785	6					40
97288	85000	28.5622	80.5785	54	64	8.9			40
97288	85000	28.5836	80.5842	6					41
97288	85000	28.5836	80.5842	54	48	12.1			41
97288	85000	28.5130	80.5613	6			78	68	61
97288	85000	28.5130	80.5613	12	60	4.1			61
97288	85000	28.5130	80.5613	54	67	8.0	76	64	61
97288	85000	28.5130	80.5613	162	67	14.0			61
97288	85000	28.5130	80.5613	204	71	14.0	78	72	61
97288	85000	28.5130	80.5613	6			77	65	62
97288	85000	28.5130	80.5613	12	56	4.1			62
97288	85000	28.5130	80.5613	54	59	8.0	78	65	62
97288	85000	28.5130	80.5613	162	60	14.0			62
97288	85000	28.5130	80.5613	204	64	13.0	78	64	62
97288	85000	28.5358	80.5747	6			77		108
97288	85000	28.5358	80.5747	12	77	1.9			108
97288	85000	28.5358	80.5747	54	66	6.0	78		108
97288	85000	28.6141	80.6203	6			78		112
97288	85000	28.6141	80.6203	12	55	6.0			112
97288	85000	28.6141	80.6203	54	54	9.9	79		112
97288	85000	28.4048	80.6519	6			79	70	300
97288	85000	28.4048	80.6519	54	48	8.9			300
97288	85000	28.4600	80.5711	6			73		303
97288	85000	28.4600	80.5711	12	62	1.9			303
97288	85000	28.4600	80.5711	54	56	5.1	76		303
97288	85000	28.6027	80.6414	6			77		311
97288	85000	28.6027	80.6414	12	41	4.1			311
97288	85000	28.6027	80.6414	54	57	6.0	77		311
97288	85000	28.6105	80.6069	6					393
97288	85000	28.6105	80.6069	60	61	11.1	78	68	393
97288	85000	28.6057	80.6016	6			77	66	394
97288	85000	28.6057	80.6016	60	63	11.1	78	67	394
97288	85000	28.6294	80.6235	6					397
97288	85000	28.6294	80.6235	60	62	15.9	81	-42	397
97288	85000	28.6248	80.6182	6			77	66	398
97288	85000	28.6248	80.6182	60	57	9.9	78	67	398
97288	85000	28.4586	80.5923	6			73		403
97288	85000	28.4586	80.5923	12	60	2.9			403
97288	85000	28.4586	80.5923	54	57	6.0	78		403
97288	85000	28.6062	80.6739	6			73		412
97288	85000	28.6062	80.6739	12	26	2.9			412
97288	85000	28.6062	80.6739	54	41	6.0	76		412
97288	85000	28.6586	80.6998	6			74		415
97288	85000	28.6586	80.6998	12	45	1.9			415
97288	85000	28.6586	80.6998	54	52	5.1	76		415
97288	85000	28.7055	80.7265	6			78	68	418
97288	85000	28.7055	80.7265	54	43	7.0			418

97288	85000	28.7755	80.8043	6			77	69	421
97288	85000	28.7755	80.8043	54	50	4.1			421
97288	85000	28.5158	80.6400	6			75		506
97288	85000	28.5158	80.6400	12	46	2.9			506
97288	85000	28.5158	80.6400	54	66	5.1	77		506
97288	85000	28.5623	80.6694	6			70		509
97288	85000	28.5623	80.6694	12	29	1.0			509
97288	85000	28.5623	80.6694	54	43	4.1	75		509
97288	85000	28.5986	80.6817	6					511
97288	85000	28.5986	80.6817	30	34	4.1			511
97288	85000	28.6160	80.6930	6			72	67	512
97288	85000	28.6160	80.6930	30	38	4.1			512
97288	85000	28.6307	80.7027	6					513
97288	85000	28.6307	80.7027	30	45	4.1			513
97288	85000	28.6431	80.7482	6			68		714
97288	85000	28.6431	80.7482	12	351	1.0			714
97288	85000	28.6431	80.7482	54	29	4.1	75		714
97288	85000	28.4632	80.6702	6			66		803
97288	85000	28.4632	80.6702	12	346	0.0			803
97288	85000	28.4632	80.6702	54	30	2.9	73		803
97288	85000	28.5184	80.6962	6			75		805
97288	85000	28.5184	80.6962	12	345	1.0			805
97288	85000	28.5184	80.6962	54	22	2.9	73		805
97288	85000	28.7464	80.8707	6			68	67	819
97288	85000	28.7464	80.8707	54	324	1.9			819
97288	85000	28.4079	80.7604	6			67	66	1000
97288	85000	28.4079	80.7604	54	341	4.1			1000
97288	85000	28.5272	80.7742	6			78	71	1007
97288	85000	28.5272	80.7742	54	31	7.0			1007
97288	85000	28.6056	80.8248	6			69	67	1012
97288	85000	28.6056	80.8248	54	22	1.9			1012
97288	85000	28.5697	80.5864	6			77	67	1101
97288	85000	28.5697	80.5864	12	53	5.1			1101
97288	85000	28.5697	80.5864	54	55	8.9	78	66	1101
97288	85000	28.5697	80.5864	162	58	14.0			1101
97288	85000	28.5697	80.5864	204	56	14.0	78	64	1101
97288	85000	28.5697	80.5864	6			77	67	1102
97288	85000	28.5697	80.5864	12	50	2.9			1102
97288	85000	28.5697	80.5864	54	55	8.9	78	65	1102
97288	85000	28.5697	80.5864	162	49	13.0			1102
97288	85000	28.5697	80.5864	204	53	14.0	78	65	1102
97288	85000	28.4843	80.7856	6			67	66	1204
97288	85000	28.4843	80.7856	54	326	1.9			1204
97288	85000	28.6445	80.9034	6					1215
97288	85000	28.4114	80.9284	6			62	62	1500
97288	85000	28.4114	80.9284	54	338	2.9			1500
97288	85000	28.4475	80.8538	6					1502
97288	85000	28.4960	80.8843	6					1605
97288	85000	28.4960	80.8843	54					1605
97288	85000	28.5583	80.9132	6					1609
97288	85000	28.6173	80.9581	6			69	69	1612
97288	85000	28.6173	80.9581	54	342	5.1			1612
97288	85000	28.6762	80.9987	6			67	67	1617
97288	85000	28.6762	80.9987	54	19	4.1			1617
97288	85000	28.5231	81.0100	6			65	65	2008
97288	85000	28.5231	81.0100	54	340	2.9			2008
97288	85000	28.6489	81.0693	6			64	64	2016
97288	85000	28.6489	81.0693	54	323	1.0			2016

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97288   85000   28.4417   81.0291     6                            2202
97288   85000   28.4417   81.0291    54                            2202
97288   85000   28.6256   80.6571     6                    74   65 3131
97288   85000   28.6256   80.6571    12    49    1.9                3131
97288   85000   28.6256   80.6571    54    62    6.0      76   64 3131
97288   85000   28.6256   80.6571   162    63    9.9                3131
97288   85000   28.6256   80.6571   204    66   11.1      78   64 3131
97288   85000   28.6256   80.6571   295    63   12.1                3131
97288   85000   28.6256   80.6571   394    61   12.1                3131
97288   85000   28.6256   80.6571   492    55   12.1      76   64 3131
97288   85000   28.6256   80.6571     6                    74   65 3132
97288   85000   28.6256   80.6571    12    48    1.0                3132
97288   85000   28.6256   80.6571    54    59    6.0      76   65 3132
97288   85000   28.6256   80.6571   162    62   11.1                3132
97288   85000   28.6256   80.6571   204    65   12.1      78   64 3132
97288   85000   28.6256   80.6571   295    61   12.1                3132
97288   85000   28.6256   80.6571   394    60   12.1                3132
97288   85000   28.6256   80.6571   492    61    9.9      76   63 3132
97288   85000   28.3932   80.8211     6                    69   68 9001
97288   85000   28.3932   80.8211    54   351    2.9                9001
97288   85000   28.3382   80.7321     6                    70   68 9404
97288   85000   28.3382   80.7321    54   109    1.0                9404
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Meteorological Tower Data - 15 October 1997 0900Z

DAY	TIME	LAT	LON	Z	DIR	SPD	T	TD	TIDN
97288	90000	28.4338	80.5734	6			74		1
97288	90000	28.4338	80.5734	12	34	1.0			1
97288	90000	28.4338	80.5734	54	54	7.0	76		1
97288	90000	28.4443	80.5621	6			75	65	2
97288	90000	28.4443	80.5621	12	59	2.9			2
97288	90000	28.4443	80.5621	54	62	7.0	77	65	2
97288	90000	28.4443	80.5621	90	67	8.9			2
97288	90000	28.4443	80.5621	162	69	11.1			2
97288	90000	28.4443	80.5621	204	67	13.0	78	64	2
97288	90000	28.4443	80.5621	6			75	65	2
97288	90000	28.4443	80.5621	12	56	2.9			2
97288	90000	28.4443	80.5621	54	62	7.0	77	65	2
97288	90000	28.4443	80.5621	90	63	8.9			2
97288	90000	28.4443	80.5621	162	68	11.1			2
97288	90000	28.4443	80.5621	204	65	12.1	78	68	2
97288	90000	28.4598	80.5267	6			78		3
97288	90000	28.4598	80.5267	12	64	9.9			3
97288	90000	28.4598	80.5267	54	64	12.1			3
97288	90000	28.4466	80.5652	6					17
97288	90000	28.7435	80.7005	6			80	70	19
97288	90000	28.7435	80.7005	54	42	12.1			19
97288	90000	28.7975	80.7378	6			80	69	22
97288	90000	28.7975	80.7378	54	59	11.1			22
97288	90000	28.4721	80.5393	6					36
97288	90000	28.4721	80.5393	90	70	13.0			36
97288	90000	28.5622	80.5785	6					40
97288	90000	28.5622	80.5785	54	60	8.9			40
97288	90000	28.5836	80.5842	6					41
97288	90000	28.5836	80.5842	54	49	9.9			41
97288	90000	28.5130	80.5613	6			78	69	61
97288	90000	28.5130	80.5613	12	59	4.1			61

97288	90000	28.5130	80.5613	54	72	8.0	76	64	61
97288	90000	28.5130	80.5613	162	72	14.0			61
97288	90000	28.5130	80.5613	204	74	14.0	78	72	61
97288	90000	28.5130	80.5613	6			77	66	62
97288	90000	28.5130	80.5613	12	58	4.1			62
97288	90000	28.5130	80.5613	54	63	8.0	78	66	62
97288	90000	28.5130	80.5613	162	64	13.0			62
97288	90000	28.5130	80.5613	204	68	13.0	78	64	62
97288	90000	28.5358	80.5747	6			76		108
97288	90000	28.5358	80.5747	12	60	1.9			108
97288	90000	28.5358	80.5747	54	55	5.1	77		108
97288	90000	28.6141	80.6203	6			78		112
97288	90000	28.6141	80.6203	12	59	6.0			112
97288	90000	28.6141	80.6203	54	59	8.9	79		112
97288	90000	28.4048	80.6519	6			78	70	300
97288	90000	28.4048	80.6519	54	55	8.9			300
97288	90000	28.4600	80.5711	6			72		303
97288	90000	28.4600	80.5711	12	54	1.9			303
97288	90000	28.4600	80.5711	54	56	5.1	76		303
97288	90000	28.6027	80.6414	6			78		311
97288	90000	28.6027	80.6414	12	46	4.1			311
97288	90000	28.6027	80.6414	54	55	7.0	77		311
97288	90000	28.6105	80.6069	6					393
97288	90000	28.6105	80.6069	60	54	12.1	78	67	393
97288	90000	28.6057	80.6016	6			77	66	394
97288	90000	28.6057	80.6016	60	62	9.9	78	67	394
97288	90000	28.6294	80.6235	6					397
97288	90000	28.6294	80.6235	60	62	15.9	81	-41	397
97288	90000	28.6248	80.6182	6			77	66	398
97288	90000	28.6248	80.6182	60	62	11.1	78	67	398
97288	90000	28.4586	80.5923	6			73		403
97288	90000	28.4586	80.5923	12	59	1.9			403
97288	90000	28.4586	80.5923	54	56	6.0	78		403
97288	90000	28.6062	80.6739	6			74		412
97288	90000	28.6062	80.6739	12	26	4.1			412
97288	90000	28.6062	80.6739	54	42	6.0	76		412
97288	90000	28.6586	80.6998	6			74		415
97288	90000	28.6586	80.6998	12	40	1.9			415
97288	90000	28.6586	80.6998	54	47	4.1	76		415
97288	90000	28.7055	80.7265	6			78	69	418
97288	90000	28.7055	80.7265	54	45	6.0			418
97288	90000	28.7755	80.8043	6			77	69	421
97288	90000	28.7755	80.8043	54	50	4.1			421
97288	90000	28.5158	80.6400	6			76		506
97288	90000	28.5158	80.6400	12	44	2.9			506
97288	90000	28.5158	80.6400	54	61	6.0	77		506
97288	90000	28.5623	80.6694	6			70		509
97288	90000	28.5623	80.6694	12	28	1.9			509
97288	90000	28.5623	80.6694	54	44	5.1	75		509
97288	90000	28.5986	80.6817	6					511
97288	90000	28.5986	80.6817	30	39	4.1			511
97288	90000	28.6160	80.6930	6			71	67	512
97288	90000	28.6160	80.6930	30	47	4.1			512
97288	90000	28.6307	80.7027	6					513
97288	90000	28.6307	80.7027	30	48	5.1			513
97288	90000	28.6431	80.7482	6			68		714
97288	90000	28.6431	80.7482	12	17	1.0			714
97288	90000	28.6431	80.7482	54	38	5.1	75		714

97288	90000	28.4632	80.6702	6			66		803
97288	90000	28.4632	80.6702	12	341	1.0			803
97288	90000	28.4632	80.6702	54	18	1.9	73		803
97288	90000	28.5184	80.6962	6			76		805
97288	90000	28.5184	80.6962	12	3	1.0			805
97288	90000	28.5184	80.6962	54	24	2.9	73		805
97288	90000	28.7464	80.8707	6			68	67	819
97288	90000	28.7464	80.8707	54	331	1.9			819
97288	90000	28.4079	80.7604	6			67	66	1000
97288	90000	28.4079	80.7604	54	351	5.1			1000
97288	90000	28.5272	80.7742	6			78	71	1007
97288	90000	28.5272	80.7742	54	27	7.0			1007
97288	90000	28.6056	80.8248	6			69	67	1012
97288	90000	28.6056	80.8248	54	26	1.9			1012
97288	90000	28.5697	80.5864	6			77	67	1101
97288	90000	28.5697	80.5864	12	53	4.1			1101
97288	90000	28.5697	80.5864	54	51	8.9	78	66	1101
97288	90000	28.5697	80.5864	162	57	13.0			1101
97288	90000	28.5697	80.5864	204	54	13.0	78	64	1101
97288	90000	28.5697	80.5864	6			77	67	1102
97288	90000	28.5697	80.5864	12	50	4.1			1102
97288	90000	28.5697	80.5864	54	51	8.0	78	65	1102
97288	90000	28.5697	80.5864	162	48	12.1			1102
97288	90000	28.5697	80.5864	204	52	13.0	78	64	1102
97288	90000	28.4843	80.7856	6			67	66	1204
97288	90000	28.4843	80.7856	54	325	1.0			1204
97288	90000	28.6445	80.9034	6					1215
97288	90000	28.4114	80.9284	6			63	62	1500
97288	90000	28.4114	80.9284	54	341	2.9			1500
97288	90000	28.4475	80.8538	6					1502
97288	90000	28.4960	80.8843	6					1605
97288	90000	28.4960	80.8843	54					1605
97288	90000	28.5583	80.9132	6					1609
97288	90000	28.6173	80.9581	6			69	69	1612
97288	90000	28.6173	80.9581	54	355	5.1			1612
97288	90000	28.6762	80.9987	6			67	67	1617
97288	90000	28.6762	80.9987	54	22	5.1			1617
97288	90000	28.5231	81.0100	6			67	67	2008
97288	90000	28.5231	81.0100	54	356	2.9			2008
97288	90000	28.6489	81.0693	6			64	64	2016
97288	90000	28.6489	81.0693	54	326	1.0			2016
97288	90000	28.4417	81.0291	6					2202
97288	90000	28.4417	81.0291	54					2202
97288	90000	28.6256	80.6571	6			74	65	3131
97288	90000	28.6256	80.6571	12	48	1.9			3131
97288	90000	28.6256	80.6571	54	56	6.0	76	65	3131
97288	90000	28.6256	80.6571	162	55	9.9			3131
97288	90000	28.6256	80.6571	204	56	9.9	78	65	3131
97288	90000	28.6256	80.6571	295	55	12.1			3131
97288	90000	28.6256	80.6571	394	53	13.0			3131
97288	90000	28.6256	80.6571	492	47	13.0	76	64	3131
97288	90000	28.6256	80.6571	6			74	66	3132
97288	90000	28.6256	80.6571	12	44	1.9			3132
97288	90000	28.6256	80.6571	54	54	5.1	77	65	3132
97288	90000	28.6256	80.6571	162	54	8.9			3132
97288	90000	28.6256	80.6571	204	57	9.9	78	65	3132
97288	90000	28.6256	80.6571	295	54	11.1			3132
97288	90000	28.6256	80.6571	394	54	13.0			3132

97288	90000	28.6256	80.6571	492	52	9.9	75	64	3132
97288	90000	28.3932	80.8211	6			69	68	9001
97288	90000	28.3932	80.8211	54	349	2.9			9001
97288	90000	28.3382	80.7321	6			70	69	9404
97288	90000	28.3382	80.7321	54	333	1.0			9404